A PRIMER
FOR
GARRISON ARTILLERY

DOWNES


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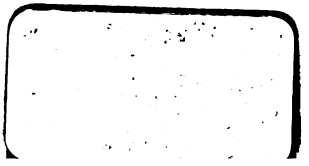

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By M. F. DOWNES,

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PREFACE.

TO THE GARRISON GUNNERS.

In order for the Garrison Gunner to acquire the large amount of information now necessary to make him efficient, he has to wade through a number of books not always ready at hand.

I have therefore endeavoured herein somewhat to concentrate that information and render him assistance in preparing for the annual examination on the subject of Skill at Arms.

The subjects are arranged under the same headings as in Regimental Order, Horse Guards, War Office, 1st August, 1876.

M. F. DOWNES,
Major, Royal Artillery.

Woolwich,
November, 1876.

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A PRIMER

FOR

GARRISON ARTILLERY.

I.

EXPLANATION OF THE TERMS ORDINARILY USED IN GUNNERY.

Ammunition means anything and everything that is expended when firing a gun.

Ammunition Entrance.—The entrance to the magazine for ammunition (gunpowder) only.

Ammunition Passage.—A passage along which both powder and shell are transported.

Angle of Departure is the angle a tangent to the trajectory makes with the line of sight when the projectile leaves the muzzle. Owing to the jump of the gun, this is usually some minutes in excess of the angle of elevation.

Angle of Descent is the angle made by a tangent to the trajectory with a horizontal plane at the point of impact. It varies from about one-fifth to one-third more than the angle of elevation.

Angle of Elevation is the angle which the line of fire makes with the line of sight.

Artillery General Store.—A store for the reception of the spare gun stores of all natures.

Attending to Vent means drifting and placing the plug in the vent.

Axis of Gun is an imaginary line passing down the centre of the bore.

Axis of Trunnions is an imaginary line passing through the centre of the trunnions at right angles to the axis of the gun.

Barbette Battery.—When the interior of a fort is so raised that guns can fire over the parapet without cutting embrasures.

Bending.—Bending ropes together consists in uniting them in such a manner that, whilst they bite more readily, they can also be separated more easily than when knotted.

Blocks, Admiralty, are simple wooden shells bound on the outside, in the direction of their length, with a rope strap, which is called "the strap" of the block.

Blocks, Bothway's, are iron strapped, the strapping passing inside the shell, and affording a better support to the pin, upon which the sheaves turn, than the Admiralty block does. These blocks are fitted with swivel hooks.

Blocks are designated by the length of their shell measured on the outside, and by the number of sheaves. The blocks used in the Artillery service are single, double, treble, and snatch, and are of the following dimensions: 18, 15, 12, 10, 9, and 8 inch.

Blocks will take a rope the circumference of which is equal to one-third of their length; thus, an 18″ block can take a 6″ rope.

Sheaves of blocks should work quite true on the pins, which should from time to time be examined. The shell of a block in use should not press against anything.

Calibre is the diameter of the bore measured across the lands in R.M.L. guns; across the grip in R.B.L. guns.

Cannelure.—A shallow groove running round the exterior of the leaden coating of the B.L. shell, in order to receive the lead stripped from the coating in its passage through the bore.

Cartridge Issuer.—A hatch in a door, or opening in a wall, through which cartridges are passed.

Cartridge Recess.—A small receptacle for the storage of a few cartridges for the immediate service of a gun.

Cartridge Serving Room.—A chamber on the same level as the gun into which the cartridge lifts lead, and from which the service of cartridges is conducted.

Centring.—The projectile in loading bears on one side of the stud, which is called the "loading edge;" in firing it bears against the other side, which is called the "driving edge." If the driving edge of the stud be made an inclined plane and the side of the groove corresponding in shape, the stud, on being pressed against the groove, will have a tendency to run up the inclined plane, and by so doing will centre the projectile in the bore; that is, will bring the axis of the projectile to correspond with the axis of the gun.

Chains.—Previous to the employment of a chain, every link should be most carefully examined.

To calculate the safe working load for an iron chain, square the diameter of the chain in eighths of inches, and cut off the last figure as a decimal. Thus, in a 1″ chain—

$$1'' = \tfrac{8}{8},\ 8^2 = 64, \text{ or } 6{\cdot}4 \text{ tons.}$$

Chamber is a conical cavity at the bottom of the bore, to receive the cartridge.

Clearance is the difference between the projection of the stud and the depth of the groove.

Clearance Angle is the angle of elevation attained when a line passed from top of tangent scale, elevated to the highest number of degrees marked on it, to notch on muzzle, just coincides with apex or tip of dispart sight.

Clinches.—Clinching is a method of fastening ropes by a knot and seizings, and is used for the breeching of guns, attaching the standing end of the fall to the block in tackles, &c.

Clinometers are instruments used for determining the angles of slopes, also for giving elevation to guns if required.

Counterscarp is the wall which keeps up the earth on the side of ditch furthest from the interior of fort.

Deflection is the horizontal distance of the first graze of a projectile, measured to the right or left, perpendicularly to the plane of fire.

Derivation.—*See* "Permanent Deflection."

Dispart is half the difference between the diameters of those parts of a gun on which the sights are placed; or the difference between the radii of the gun at those parts.

Embrasure.—An opening cut in a parapet, through which to fire guns.

Escarp is the wall which keeps up the earth and parapet on the side of ditch nearest the interior of fort.

Expense Cartridge Store.—A cartridge store appropriated for the service of particular guns, and from which the service of a gun or guns is conducted.

Fire, Natures of.—There are two classes, horizontal and vertical. The latter is from mortars, usually at an angle of 45°.

Horizontal Fire is from guns mounted in the ordinary way, and rifled howitzers on their travelling carriages with the wheels on.

Horizontal fire may be thus classified, viz.:—

Cross.—When the fire of two or more guns or batteries in different positions is concentrated upon one point.

Direct.—When the line of fire makes an angle of from 60° to 90° with the front of object fired at.

Enfilade.—When the line of fire of guns fired with the full service charge is parallel, or nearly so, to front of object fired at.

Indirect or Curved.—From rifled guns to breach walls or reach troops under cover of a hill, &c., the line of fire will be usually more or less direct; but the guns have to be fired at high angles with reduced charges, so as to clear intervening obstacles, and then descend when required. When firing from high parapets without embrasures, the fire will be of the same nature.

Oblique.—When the line of fire is at an angle of 60° or less.

Reverse.—When the line of fire takes the object fired at in rear.

Ricochet.—When the line of fire is as with enfilade; but the guns are fired with reduced charges and high elevation, so as to clear some intervening obstacle, and allow the shot to ricochet in short bounds along the works, dismounting guns, etc. Applies only to S.B. guns.

Vertical Fire.—The rifled howitzers will in time replace mortars for vertical fire at angles from 20° to 40°.

Fishing Spars consists in strengthening spars by lashing other spars parallel to them.

Frapping is the drawing together the several returns of a rope.

Friction.—The resistance which a body meets with from the surface on which it moves.

Fulcrum.—The term "fulcrum" means a support for a lever.

Gas Checks are rings of copper fastened mechanically on to the base of the projectile; these being compressed by the action of the gas into the grooves decrease the windage to a large amount, prevent scoring, and increase range and accuracy.

General Lift.—A description of lift larger than that for cartridges or shell, through which powder in bulk may be passed.

Gravity.—That force or universal law by which all bodies and particles of matter are attracted towards each other.

Gravity, Centre of.—The point in which the weight of the body centres.

Gravity, Force of.—The tendency of everything to fall in a straight line towards the centre of the earth. A body falls (omitting fractions) 16 feet the first second, 64 feet at the end of the second second = 16×2^2, and so on; or the fall increases according to the square of the time in seconds.

Gravity, Specific.—The weight of one body compared with that of another of equal bulk taken as a standard. The standard for all bodies except gases is pure distilled water at 60° temperature.

Gun, to slew the Trunnions of.—Is to turn the gun on its axis, so as to bring the gun into any required position.

To cut is to cause it to move horizontally, without rolling, by moving breech and muzzle alternately in the required direction.

To parbuckle is to roll a gun by means of ropes passing round it.

To pinch is to move a gun by small heaves of the handspike, without allowing it to turn on its axis.

To row is to move a gun in the direction of its length.

To slew end for end is to turn it round, not allowing it to revolve on its longer axis.

Hitches may be described as overlaying a part of a rope with itself in such a manner that a loop or loops are formed to jam on each other.

Inertia.—A property of matter by which it cannot of itself put itself in motion, or, if in motion, has no power within itself to alter the direction or magnitude of its motion.

Laboratory.—A building or buildings with passages leading thereto, in which ammunition is examined, cartridges made up, and shells filled.

Levers.—1st order: When the fulcrum upon which lever rests is between the weight and the power applied to move it.

2nd order: When the weight is between the power and the fulcrum.

Line of Fire is the prolongation of the axis of the gun.

Line of Sight is the line passing through the notch of the tangent scale and apex of the dispart sight to the object.

Magazine.—Building or buildings with passages leading thereto, in which powder in bulk, filled cartridges, or shell are stored.

Magazine Store.—A chamber within a magazine (if provided), in which the hides, wadmil-tilts, and spare magazine clothing may be kept.

Momentum.—The quantity of motion in a moving body. This is always equal to the mass (weight), multiplied by the velocity. The force with which a shot strikes depends on its weight and velocity.

Mousing is to seize the point and back of a hook, in order to prevent its disengaging itself from anything to which it may be hooked.

Pedestals.—Cylindrical pieces of elm used to support the stool-beds of carriages when the elevating screws are removed.

Permanent Deflection, sometimes called Derivation, is the peculiar deviation that elongated projectiles fired from a rifled gun are subject to, the rotation causing them to bear away to the right or left, according to the twist of the rifling. This deflection being constant, allowance is made for it by inclining the tangent scale to the left, at an angle called the permanent "angle of deflection," as determined by actual practice at Shoeburyness; all guns in the English service being rifled from left to right, the rotation therefore tends to deflect the projectile to the right. As a general rule, ricochets are found to be in the same direction.

Perpendiculars are for determining the position of the axis of a mortar.

Plane of Fire is the vertical plane passing through the axis of the gun.

Pointblank.—A gun is said to be laid pointblank, when the production of its axis will pass through the object aimed at, which may be above or below the gun.

Pointing is to taper the end of a rope, so that it can more easily enter a hole or block.

Preponderance is the excess of weight in rear of the trunnions, which is in rifled built-up guns reduced to a minimum, to allow the breech to be easily elevated.

Quadrants are instruments used to give elevation to guns.

Range is the distance from the muzzle to the second intersection of the line of sight and the trajectory.

Range, Mean, is found by adding all the ranges together, and dividing by the sum of the number of projectiles fired.

Rifling, System of, is the means adopted to give rotation to a projectile round an axis coincident with that of the bore. There are two systems of rifling in the English service, viz.:

(1.) Muzzle-loading guns, having soft metal studs to fit the grooves.

(2.) Breech-loading guns, with projectiles having a soft metal coating larger in diameter than the bore, which is compressed by the gas into the form of the bore.

Successful experiments have lately been carried on to give the rotation by means of a saucer-shaped gas check attached to the base of the projectile.

Rope.—A certain proportion of fibres of hemp twisted together form a yarn, and a number of yarns form a strand. Three strands twisted together form a rope. The size of a rope depends upon the number of yarns contained in it.

Rope is issued either white or tarred—the latter being most serviceable when liable to be exposed to the wet, the former when not so exposed. Rope is designated by its circumference expressed in inches. That made in her Majesty's dockyards is distinguished by a coloured thread running through each strand.

New rope is made up in coils, coiled from left to right, of about 113 fathoms each.

To find the weight of rope, multiply the square of the circumference in inches by the length in fathoms, and divide by 480, for the weight in cwts.

To calculate the working strain of new rope, square the circumference, and divide by seven for the strain in tons; with rope much worn divide by eight.

Place no reliance on a stranded rope which presents an unusually uneven surface.

Scoring or Guttering is caused by the rush of gas through the windage, causing the metal of the barrel to be eaten away into irregnlar furrows and ridges.

Seizing is to connect two parts of a rope together with lashing.

Shifting Room, or Shifting Lobby.—The chamber, or portion of the entrance passage, to be devoted to putting on or taking off magazine or laboratory clothing.

Side Arms means sponge, rammer, wad-hook, and shell-extractor.

Splicing is to join one end of a rope to any other part by interweaving the strands in a regular manner.

"*Stand fast!*"—1. At drill every member will remain steady in the position in which he is until "go on" is given.

2. In action or at practice, at this order a gun, if loaded, will remain so; if being loaded, the loading will be finished, In either case the gun will not be fired until the order is given.

Stores.—By this term is meant anything that may be required for the working of a gun but is not expended by firing.

Tackle.—A simple tackle consists of one or more blocks rove with a single rope or "fall." The fixed end is called the "standing end" of the fall; the end hauled upon is the "running end."

Each separate part of the fall contained between two blocks, or between either extremity and a block, is called "a return" of the fall.

To "overhaul" a tackle is to separate the blocks.

To "round in" a tackle is to bring the blocks closer together by hauling in the fall.

To "rack" a tackle is to fasten any two opposite returns of a tackle together, so that the blocks may retain their relative position, although the running end be let go.

Tackles.—1. One fixed block: no mechanical advantage.

2. One movable block: which doubles the power.

3. "A luff tackle" consists of a double and single 8-inch block, with a fall of $2\frac{1}{2}$-inch rope, which, when the single block is movable, trebles the power; when the double, it increases the power fourfold.

4. "A gun tackle" consists of two double blocks. Power four or five to one, as used.

5. "A heavy gun tackle," or "light gyn tackle," consists of a double and treble block, which increases the power five or six times, as used.

6. "A medium or heavy gyn tackle" consists of two treble blocks, and a power of six or seven is gained.

7. "A whip upon whip" consists of two movable blocks, one of which is applied to and acts upon the running of the fall of the other. It increases the power fourfold.

8. "A runner tackle" is a tackle applied to the end of a rope passing through another block.

In a combination of "tackles," where one acts upon the running end of the other, the result of their combined action is found by multiplying together the values of the several simple tackles.

Trajectory is the curved line described by the centre of gravity of a projectile in its passage through the air.

Traverse is a mass of earth, or earth covering masonry, built up between guns to protect them from enfilade or ricochet fire.

Twist.—The inclination or angle of the rifling is called the "twist." This is either uniform or increasing; it is measured by the length or distance in which one complete turn is made. With a uniform twist the inclination is the same throughout the bore; with an increasing spiral or twist the inclination is termed "uniformly gaining," commencing from 0 at shell-chamber, and increasing to about 1 in 35, or 40 calibres, at the muzzle—that is to say, the inclination is such at the muzzle that one complete turn would be made in a length of 35 or 40 calibres.

"*Under cover!*"—At this command the whole of the numbers of the gun lay down their stores and double under cover.

Velocity, Final.—The velocity of the projectile at the end of any given range.

Velocity, Muzzle.—The velocity acquired by a projectile at the instant of departure from the muzzle.

Velocity of Rotation is the velocity of rotation round the axis of a projectile; this depends upon the muzzle velocity and the inclination of the rifling.

Velocity, Terminal.—The greatest velocity attainable by falling bodies, which they cannot exceed on account of the resistance of the air becoming equal to the force of gravity.

Whipping is to tie a piece of twine round the end of a rope so as to prevent it untwisting and fraying out.

Windage is the difference between the diameter of the bore of the gun and that of its projectile. The windage of all calibres of R.M.L. guns is ·08 inch; of S.B. guns, from ·10 to ·20 inch.

II.

GENERAL CONSTRUCTION AND CARE OF THE ORDNANCE, CARRIAGES, AND SIDE ARMS.

Construction of R.M.L. Guns.

Rifled guns of 7-inch calibre and upwards are designated by the calibre in inches and weight in tons; under 7-inch calibre, by the weight of the projectile.

All rifled guns in the English service, except the 7-pounder (which is of steel) and converted guns, are now made with a steel tube toughened in oil; built up over tube by means of wrought-iron coils shrunk on in a state of tension, keeping the inner portions in a state of compression.

Material.—Steel, from its hardness, high tensile strength, and freedom from flaws and defects, is better suited than wrought iron for the inner barrel of a gun, while its brittleness and uncertainty render it unsuitable for the exterior portions.

Wrought iron, though of much less tensile strength than steel when toughened in oil, is preferred for the exterior portions of rifled guns, on account of its far superior "malleability" and "ductility," thereby rendering our guns secure from explosive rupture.

Malleability is the property of being permanently extended in all directions, without rupture by pressure or by impact.

Ductility is the property of permanently extending or drawing out by traction, as in wire-drawing.

Construction of 9-inch Gun.—A 9-inch gun, which may be taken as a specimen of the general principles of construction, is thus made:—

The steel barrel, or A. tube, is cast solid, roughly bored out, then toughened in oil by being heated slightly and plunged into an oil bath; afterwards subjected to a water pressure of 8000 lbs. per square inch to test if it is any way porous.

Pigs of cast iron, after being well "puddled" to get rid of the impurities, are rolled into bars of wrought iron of various dimensions, according to the purpose for which required.

B. Tube.—The B. tube, or portion which forms the chase, is made in two parts. Each part, consisting of bars of wrought iron welded together to the right length, is then heated and

coiled round a mandrel, and after another heating each coil is welded under the steam hammer. The two parts are then turned ready (the one faced, the other recessed) for uniting. They are then united to one another in a furnace and welded under the steam hammer.

Breech Coil.—The portion of gun shrunk on to the A. tube from the trunnions to the breech is called the breech coil. It consists of a single coil, specially rolled, coiled, and welded in the usual manner.

C. Coil.—This is composed of a double coil over the breech, a single muzzle coil, and trunnion ring all welded together; the trunnion ring having in the first instance been shrunk on to the double coil, and the muzzle coil dropped into it.

The trunnion ring and cascable are forged from scrap iron.

Shrinking.—The gun has now to be put together. The A. tube is put upright in a pit, the breech coil heated to a black heat and dropped over it. To prevent the A. tube from being heated and thus expanding, a stream of cold water is forced up it.

The position of the A. tube is then reversed, and the B. tube shrunk on.

The mass is again reversed, and the C. coil is shrunk on.

By the term shrinking is understood the process of making a cylinder, which when cold would not go over another, so expand by heating that when hot it fits easily over the other, and on cooling endeavours to return to its original diameter, thereby binding with a firm attachment on to the interior cylinder, which it keeps in a state of compression.

Cascable.—The cascable, tapped as a screw, with a channel cut along the threads to show if there should be an escape of gas, is then screwed in, and the gun has only to be prepared for its sights and fittings.

With the 10-inch and heavier guns, the muzzle portion of the C. coil is welded and shrunk on to the gun separately, and is called the 1 B. coil.

With guns lighter than the 9-inch, the breech coil and C. coil are made in one, the whole going by the name of breech coil.

All R.M.L. guns to 40-pounder inclusive have an escape hole. The 25-pounder has no escape hole, as the solid end of the steel

A. tube projects beyond the breech of the jacket and forms the cascable.

Vents.—The vents of all guns, from 64-pounder inclusive and upwards, are of hardened copper, and enter the bore at a point $\frac{4}{10}$ the length of the cartridge from the rear.

The vents of 40 and 25 pounders enter at the bottom of the bore, for the purpose of firing very reduced charges.

Twist of Rifling.—All guns, up to 7-inch inclusive, and howitzers have a uniform twist. In order to prevent the studs, under the pressure of a heavy charge, overriding the grooves, guns above 7-inch have an increasing twist.

Grooves.—Guns and howitzers, 80-pounder and upwards, are rifled with the Woolwich groove. The bottom of this groove is eccentric to the bore.

The 64-pounder has the plain groove, which is similar to the narrow-deep portion of the 64-pounder shunt groove, and is used for this gun, so that it may take the 64-pounder shunt-gun ammunition.

The 40-pounder and 25-pounder have likewise the plain groove rifling.

The rifling is only continued to the breech end of the shot chamber.

The powder chamber of all guns is now made slightly conical.

Construction of Converted Guns.

The following S.B. guns are converted to R.M.L. guns, viz.:

32-pounder,	58 cwt.,	to	64-pounder,	58 cwt.
8-inch,	65 „	to	„	71 „
68-pounder,	95 „	to	80-pounder,	5 tons.

These guns have all the same calibre, and will take, if necessary, the 32-pounder S.B. ammunition.

The guns are first bored out to 10·5″ in diameter. A wrought-iron A. tube is then fitted into the gun, and secured at the muzzle by a cast-iron collar screwed in. It is prevented from shifting round by a wrought-iron or gun-metal pin being screwed into a hole drilled through the exterior metal, a short distance into the tube, underneath the gun near the trunnions.

A. Tube is formed of five coils united together in the usual manner, closed at the breech end of the bore by a forged cup.

The breech end of the tube is made in two parts, the inner portion having a spiral gas channel cut round its exterior, com-

municating with star grooves cut in the end of the tube, and the gas-escape hole drilled through the cast-iron breech.

The tube is made double in this part, in order that the gas may escape through the gas channel without bursting the gun, in the event of the inner portion splitting.

Additional strength is likewise gained where the gun is subjected to the greatest strain.

The axis of the trunnions of all rifled built-up guns is in the same horizontal plane as that of gun, and but little preponderance is given.

Construction of R.B.L. Guns.

As it is several years since any of these were constructed, a few only have steel barrels, but are altogether of wrought iron.

The barrels are all polygrooved; and as the "lands" and grooves are all the same size, the number of grooves varies with the calibre.

The bore, or barrel, has four different diameters—the powder chamber; the shot chamber; the grip, which is the smallest of all, and by which the calibre is determined; then the remainder of bore to muzzle is lapped out ·005″, for the purpose of easing the gun when the projectile is forced through it.

Vent-Pieces have been made of steel, but were constructed finally of Marshall's refined iron.

N.B.—An old-pattern vent-piece, having a flat back, should never (if possible) be used.

The "beak" on vent-piece of 7-inch and 40-pounder is to prevent the "nose" on the face being injured when the vent-piece is being put in.

The 40-pounder vent-piece has a copper ring on the nose; that for the 7-inch has no copper ring, but a more projecting nose. Tin cups must always be used with the 7-inch gun.

Breech Screw is made of steel for 40-pounder; of iron, with a steel face 6 inches long, for the 7-inch.

Tappet Ring is made of wrought iron, has projections (tappets) on it to enable lever to act against it when screwing or unscrewing breech screw.

Levers are of wrought iron, and are fitted with weight-balls, or accumulators, to give power in screwing up.

Keep Pins are of steel, slotted near the centre, and punched out so as to form a spring to keep them in their places.

Indicator Ring.—A thin narrow ring of wrought iron, fitted on the breech screw in front of the tappet ring. It should be

so adjusted on the screw that, when the vent-piece is properly screwed up, the raised line of brass on the ring and on the top of the breech-piece must coincide.

A B.L. gun consists of a forged breech-piece, a forged trunnion-piece, and one or more coils according to its size.

Wrought-Iron Carriages.

Sliding carriages for all guns of seven tons weight and upwards are constructed of wrought iron.

There are at the present moment in the service wrought-iron carriages of two distinct constructions, comprising several different patterns.

The first two patterns issued were of the single-plate construction, where the brackets are formed of a single plate of iron riveted to an open framework of angle iron.

The last pattern is of the double-plate construction, where the brackets are formed of two plates of iron riveted to a framework of bar iron fitted between them.

Single-Plate Carriages, 1st Pattern.—Single-plate carriages of the first pattern were made for the 9 and 7 inch guns. They were made of different heights, dwarf and casemate, for the same nature of gun; the former being suitable for L.S. only.

The compressor arrangement was that known as the American, and was worked by hand wheels fitted on the outside of each bracket.

2nd Pattern.—The carriages of the next pattern, of which there are a large number in the service, were made for the 12, 9, 8, and 7 inch R.M.L. guns.

These carriages were fitted with the Elswick compressor.

Maximum Elevation or Depression.—The maximum elevation or depression that can be given by the carriages is as follows:—

12-inch	gun—	elevation	15°	...	depression	5°
9	„	„	„	15°	...	„	5°
8	„	„	„	15°	...	„	5°
7	„	„	„	14°	...	„	5°

American Compressor.—Five wooden baulks are fitted down the middle of the platform. Six iron compressor plates, strung on pins from the angle plate, which is bolted to the blocks fastened to the framework of the carriage, hang down between the wooden baulks. By turning the hand wheels on both sides of the carriage, the lower arms of the rocking levers are forced inwards against the outer compressor plates, thereby

jamming the whole of the plates and movable baulks against the centre baulk, which is the only fixture. The friction produced between these on the discharge of the gun checks the recoil.

Elswick Compressor.—Six iron bars are fitted along the platform instead of the wooden baulks, and the compressor plates (seven in number for the 7, 8, and 9 inch guns; eight bars and nine plates for the 10, 11, and 12 inch guns) are suspended between them.

An adjusting lever is put on the left side of the carriage at about 45°, and keyed; the compressor lever on the right side of the carriage is put on vertical.

If the compressor lever, when thrown down, goes tightly under the catch, it is correct; if it goes down easily, and the rocking levers do not press the plates together, raise the adjusting lever. If it is found that the adjusting lever cannot give it sufficient compression, throw both levers horizontal, and remove the compressor lever; place it on another face of the compressor screw, the end of which is made hexagonal for this purpose, and the adjusting lever will now be found to give the requisite compression.

Double-Plate Carriages.—Are now made for all guns of 6 tons weight and upwards. There is but one carriage for each nature of gun, which is used both as dwarf and casemate, the difference in height being given by the platform. Those for 10-inch R.M.L. and 35-ton are known as Scott's. The same carriage serves for either casemate or open battery.

Wrought-iron sliding carriages for land service are now fitted with a hydraulic buffer, and for this purpose an iron flange, with a circular hole in it for the reception of the end of the piston rod, is bolted on the under side of the centre of the carriage in front.

The capstan head, with jamming levers and elevating gear, has now substituted for it a gear which consists of an endless screw and worm wheel, connected with the elevating arc by common toothed pinions, the whole worked by a hand wheel fixed to the shaft of the endless screw. This is supplied for guns of 12 tons weight and upwards.

Maximum Elevation or Depression is as follows:—

12-inch	gun—	elevation,	15°	...	depression,	5°
10	,,	,,	,,	10°	...	,,	5°
9	,,	,,	,,	14°	...	,,	5°
7	,,	,,	,,	20°	...	,,	5°

Hydraulic Buffer.—The same buffer is used for all natures of platforms, the only difference for any nature being the size of the four holes in the piston, viz.:

12 or 11 inch	...	...	·90 inch.
10 „	...	...	·80 „
9 „	...	...	1·00 „
7 „	...	...	1·25 „

The buffer is connected to the rear transom of platform by bands, and to the bracket on bottom plate of carriage by the piston-rod.

The quantity of Rangoon oil used is twelve gallons, and, when the carriage is run out, should be $4\frac{5}{8}$ inches deep at the filling-hole. This should always be tested before commencing to use the gun. The oil is withdrawn by means of the front cock.

For very low temperatures Field's non-freezing oil should be used.

Care must be taken to have the front clips fitted to carriage before using buffer, and removed when carriage has to be dismounted.

Action of Buffer.—The buffer being rigidly fixed to the rear of the platform, and the end of the piston-rod fixed to the front of the carriage, when the carriage is run up, the piston-rod is drawn out of the cylinder nearly its full length, the piston drawn to the front end of the cylinder, and the oil passed to the back of the piston. As the carriage recoils it forces the piston-rod with the piston up the cylinder, the oil passing from the rear to the front of the piston through the holes in it; therefore the size of the hole is regulated by the velocity of the recoil: the larger the charge the smaller the holes must be. The cylinder not being entirely filled with oil, the air in that space causes it to act as an elastic buffer.

Wrought-Iron Traversing Platforms.

Traversing Platforms are constructed of wrought iron for R.M.L. guns of 7 tons and upwards. They are constructed as dwarf and casemate platforms, identical in structure; they differ only in the height to which they are raised from the ground, and may be converted from the one to the other by changing the flange feet and trucks. Skilled artificers are necessary to do this. They are all fifteen feet in length, and have the same slope of 4°.

All platforms for double-plate carriages are of different width

between the sides, and will only receive carriages of their nature. The 7-inch platform is the only one which will take a single-plate carriage, viz. the 7 or 9 inch single-plate. They can be fitted to receive either the Elswick compressor or hydraulic buffer.

The 7-inch and 9-inch carriages are similarly constructed. The 10, 11, and 12 inch platforms are made on the "fish-bellied" system.

The traversing gear for all consists of a combination of common tooth-gearing, which acts directly on two of the four trucks of the platform, causing them to revolve and, by their friction on the racers, to traverse the platform right or left, as desired. The power of this gear varies from 69 to 1 with the 11-inch, to about 30 to 1 with the 9-inch.

Racers.—Racers for 9-inch guns and lower natures are of wrought iron, and are now laid flush with the surface; for 10-inch guns and upwards they are of steel, bevelled on their upper faces to suit the trucks.

Trucks.—The trucks are made of wrought iron, hollow-soled. The diameter of the trucks and height of the flanged feet vary with each platform, and adapt it to the several natures of pivot.

Position of Pivots for Iron Platforms.—Dwarf platforms are made for A., C., and D. pivots, the first being imaginary, the last two actual. Casemate platforms are always "A." pivot, the pivots being imaginary. The pivots are the centres from which the arcs of the racers are described.

A. pivot is 6 inches in rear of the muzzle when the gun is run up.

C., about 6·5 feet to the rear from the front of the platform.

D., about 10 feet to the rear from the front of the platform.

11 or 12 inch casemate platforms are constructed to fire over ...	...	...	3 feet	in height.
Ditto	dwarf	„	4′ 3″	„
10, 9, and 7 inch	casemate	„	2′ 6″	„
Ditto	dwarf	„	4′ 3″	„

Position of Pivots for Wooden Platforms.—The pivots for wooden platforms are—A., just under muzzle; B., just in front of the platform; C., centre of platform; D., 3 feet in rear of C.; E., 5 feet in rear of C.; F., 7 feet in rear of C.

In a casemate or open battery, where a gun fires through an embrasure, it is necessary, in order to keep the embrasure as narrow as possible, to have the pivot in the embrasure so as to have very little lateral motion to the muzzle. In open batteries,

where the gun has to cover much ground, a central or rear pivot is most suitable, the former being most convenient for a salient angle, and the latter for a face.

Racers for Wooden Platforms are of wrought iron, the upper surface being rounded off. They are raised above the ground.

Wrought-iron Standing or Rear-Chock Gun Carriages are of two natures:

No. 1 takes 64-pounder R.M.L.; 8-inch S.B.
No. 2 takes 40-pounder R.B.L.; 32-pounder S.B.

These two natures are interchangeable in all their parts, excepting the transom bolts. The trucks are of wood.

Mortar Beds are of cast iron, with wrought-iron capsquares. Each bed has a wood quoin fitted over the front transom, to give the mortar an elevation of 45°, or in some cases of 75°.

Iron Siege Artillery Carriages.

40-*pounder R.M.L.*—

	Cwt.	qrs.	lbs.
Weight of carriage, empty, about ...	24	2	0
„ limber „ „ ...	11	1	16

The track of these carriages is 5′ 2″.

The wheels are the N.P. siege. Axis of trunnion holes, 4′ 5″ in height. 35° elevation and 5° depression can be given to the gun.

64-*pounder R.M.L.*—The carriage is similar in construction to the 40-pounder.

Maximum elevation, 40°; depression, 10°.

	Cwt.	qrs.	lbs.
Weight of carriage, empty, about ...	30	2	0
„ limber „ „ ...	11	1	16

8-*inch Howitzer* is so constructed that the howitzer should be fired from the carriage with the wheels off as well as on. The elevating gear is similar to that for 40-pounder and 64-pounder, and admits of 40° elevation being given. But it is not intended to fire with the wheels on at a greater elevation than 15°, or charge of powder 5lbs. Height of axis of trunnion holes is 4′ 8½″.

	Cwt.	qrs.	lbs.
Weight of carriage, empty, about ...	42	3	14
„ limber „ „ ...	11	1	16

Wooden Siege Travelling Carriages.—There are wooden siege artillery carriages for 7-inch R.B.L., 64-pounder R.M.L., and 40-pounder R.B.L. guns, also 10-inch mortars; but all siege carriages for guns will now be made of wrought iron, which is more durable, stronger, and, if struck by a projectile, less liable to splinter, than wooden carriages.

Their track is 5′ 2″, except for the mortar, which is 4′ 3½″.

The 40-pounder R.B.L. can be given 8° elevation and 9½° depression.

Wooden Garrison Gun Carriages and Traversing Platforms.

Garrison Gun Carriages.—Three descriptions, viz. common standing, rear-chock, sliding.

Sliding carriages are either casemate or dwarf, which differ from each other only in the height of brackets.

R.M.L. guns converted from S.B. take the same carriages after as before conversion.

A common standing carriage consists of two brackets, two axletrees, a transom (all of oak), and four trucks.

To check the recoil of violent guns, such as 64-pounder R.M.L., Allen's brake is applied to each front truck. These carriages give a maximum elevation of 22° (11° with screws in) and depression of 6°.

Rear-Chock Carriages.—These carriages are used for guns which have a very violent recoil, such as the 8-inch S.B. They are made like the common standing, but instead of rear axle and trucks have a chock or block of sabicu or African oak. On the chock there is a handspike iron to take the roller handspike.

Maximum elevation without bed or screw, 27°; with screw, 17½°
„ depression ... ... 5°

Sliding Carriages have blocks of oak or sabicu to take the bearing on the platform, instead of axletrees and trucks, and are only used for guns when mounted on traversing or casemate platforms.

On a dwarf traversing platform they give, with screw in, an elevation of 10° and depression of 4° for 64-pounder, and 5° for 80-pounder R.M.L. If screw and bed are removed, an elevation of 19° can be obtained. On casemate platform, about 6° elevation and 7½° depression.

Wood Traversing Platforms are either casemate or dwarf. The same platform takes all natures of wood sliding carriages. The platforms are made entirely of teak.

A casemate platform is readily converted into a dwarf, or *vice versâ*.

The trucks are also readily altered in position from one pivot to suit any other, by simply loosening the nuts of the bolts of the flanges, setting the trucks to the new radii, and then, after the platform has been traversed from side to side, to insure the correct set of the trucks, tightening the nuts again.

Wooden Compressors.—These are used to check the recoil of the 7-inch R.B.L., 64-pounder R.M.L., 10-inch, 8-inch, or 68-pounder S.B., when mounted on a sliding carriage. They are made of three different sizes, one for the 7-inch, one for the 10-inch and 68-pounder, the other for the remaining carriages.

When not in use, the compressor should be removed from the platform to store.

Ground Platforms for Siege Service.

7-inch R.B.L. Platform.—This is formed of two oak baulks secured to two oak transoms, the front transom having a hole in it for the pivot bolt of the slide.

In laying the platform the transoms are bedded in the ground.

Clerk's Platform consists of two inclined planes, having a slope of 3°, two transoms, two sleepers, and a trail plank.

To lay the platform the sleepers and transoms are bedded flush with the ground, at right angles to the line of fire. The gun is then run into position; the wheels are raised in succession, and the inclined planes run under them and pivoted to the front transom. The trail plank is then placed under the trail. The rear transom must be so placed that, in traversing the planes, the handspikes can take a bearing upon it.

These platforms can be used for standing or rear-chock carriages.

With the latter the inclined planes are placed with the ribands on the outer sides.

Alderson's Platform consists of a number of deal baulks of the same size, oak dowels, iron shoes, pins, and screw loops. For a gun platform 58 baulks are required; for a 13-inch mortar, 54; and for a 10 or 8 inch mortar, 24.

To lay a gun platform, five sleepers are formed by placing for each two baulks end to end, overlapping these by a third, and connecting the three by dowels and shoes.

The sleepers are bedded in the ground at a slope of 3°, about

1 in 18, parallel to the line of fire. The remaining baulks, connected by dowels, are then placed over them, the front and rear baulks being secured by iron pins, and an additional baulk, to form a hurter, being laid over the front one.

To lay a 13-inch mortar platform, three sleepers are formed, each of two baulks side by side, and laid level at right angles to the line of fire. Over the sleepers the remaining baulks are laid in two tiers, at right angles to each other, the two outer baulks at each end of the upper tier being pinned to the sleepers.

For a 10 or 8 inch mortar platform, six single baulks are laid as sleepers, parallel to the line of fire, and the remaining baulks laid across them, the outer ones being pinned to the sleepers.

Transporting Carriages.

Platform Wagon carries any load to five tons. When issued to batteries of position has a waterproof canvas cover.

Sleighs are used for moving guns of 18 or 25 tons on rollers.

Sling Cart.—This cart is now made with wrought-iron fittings on windlass. Carries $3\frac{1}{4}$ tons.

Sling Wagon.—Two natures: wood sling wagon, with wrought-iron fittings, carries 6 tons; iron sling wagon carries 7 tons. Track of wheels of former, 6′ 6″; of latter, 5′ 11″.

Hand Cart takes a load of 15 cwt.

Trench Cart is painted red to distinguish it from the hand cart, and carries one ton.

Machines.

Crab Capstan.—Framework of oak, windlass of elm, capstan-bars of ash.

Winches are made of iron, and have a "single" or "double" purchase, the latter to gain greater power.

Triangle Gyns were formerly constructed of wood, but are now made of wrought iron, and with the prypole having an arched and forked end, so that the shackle can be done away with. They are as follows:—

The light 16-ft. gyn (wood) raises 70 cwt., if with wrought-iron fittings.

The light 18-ft. gyn (wood) raises 7 tons.

The heavy 18-ft. gyn (wood) raises 12 tons.
The light 18-ft. gyn (iron) raises 7 tons.
The heavy 18-ft. gyn (iron) raises 12 tons.

Sheers are of best Baltic fir. Should for a 12-ton gun be 40′ or 45′ in length, 16″ or 17″ respectively in diameter at the centre; for a 25-ton gun, 45′ long and 20″ in diameter at the centre.

Derrick.—For raising heavy sheers, should be 35′ long and 12″ in diameter at the foot.

Lifting Jacks.—The lifting jacks in the service are—the screw jack with ratchet head and lever, used for siege equipment, lifts 5 tons; the rack and pinion jack, lifts 3 tons; Haley's jack, from 2 to 20 tons; and Tangye's hydraulic jack, from 4 to 40 tons. This jack should always be kept filled, and be worked at regular intervals so as to keep it in good order. In cold weather a little spirit should be mixed with the water in the jack to prevent its freezing.

Examination of Rifled Guns.

9-inch and heavier calibres, after every 50 rounds; 8-inch, 7-inch M.L. and B.L., and 64-pounder M.L., after every 100 rounds; 64-pounder B.L. and smaller guns, after every 150 rounds.

The bores of all rifled guns from which practice is carried on should be kept slightly oiled. At the close of each day's practice they should be washed, and as soon as dry oiled with a sponge, and the muzzles closed with tampeons. When guns are not in constant use, the bores are kept lacquered, and the bright parts about the breech of B.L. guns greased.

When a gun is to be examined, the bore must be thoroughly cleaned and dried. If there is any hard rust which will not yield, one or two scaling charges should be used; no sharp-edged or pointed scrapers to be employed, as they are liable to injure the rifling.

Gutta percha impressions must be taken of all defects, except those previously entered in the "Memorandum of Examination," and in all cases of the powder and shot chambers.

The position round the gun is recorded in all cases as "up," "down," "right," "left," or in intermediate positions, as "right of down," &c., looking from the muzzle towards the breech.

The defects in wrought-iron barrels are generally numerous but unimportant, while those in steel barrels are rare, but of much moment.

In the powder chamber no defect is unimportant.

A crack in a steel barrel is sufficient to warrant provisional condemnation, but care must be taken to discriminate between a crack and a superficial streak.

Defective welds near the muzzle are of no practical moment, and no gun should be condemned on such grounds alone, although it should be exchanged when opportunity offers.

If the metal be set up in the bore, it must be filed down.

Converted cast-iron guns are more dependent than wrought-iron guns on the strength of their tubes.

The vent must be most carefully observed. After thorough cleaning, it must be gauged with the set of gauges issued. If a "choke" is found, *i.e.* metal set up in the vent near the bottom, it must be removed by a drill or rimer before the gauge is taken. When gauged, a gutta percha impression of vent must be taken.

Examination of Vents.—Original diameter of vent is ·22″.

R.M.L. guns do not require re-venting unless the ·3″ gauge passes down; nor for irregular wear at the bottom, unless the cavity measures ·5″ in diameter at the distance up the vent of ·25″ measured on the impression. They will not be ordered for re-venting on account of a hollow ring formed round the vent-bush, unless it be at least ·1″ in depth or width, or irregular or jagged, so as to be likely to retain a piece of cartridge; or on account of hair-lines radiating from the vent, unless the defect be 1 inch in length, except it is directly to the front or rear, and then the limit for condemnation will be ·5″. Heavier guns than the 9-inch will be treated exceptionally.

B.L. Guns, Examination of.—The breech screw must be examined with a straight-edge, to ascertain that the face is quite flat and true; if not, it must be filed.

The back and sides of the vent-piece must be tested by the straight-edge. The copper ring on the vent-piece, as well as the breech-bush, must be sufficiently high to prevent the action of gas on any part of the iron; if necessary, they must be refaced or replaced. The angle-face of the 7-inch vent-pieces should be flat and work truly against the end of the barrel, and the "nose" should fit closely, but not too tightly, into its place. A cavity frequently forms at the angle of the vent channel, but, unless large, is of no great importance.

The breech-bush of a B.L. gun must be renewed, if found to be so much expanded that the gas could escape between it and the tin cup or vent-piece.

If necessary, a considerable portion of the breech-screw may be removed without destroying its efficiency.

If angle-face of 7-inch vent-piece does not fit closely, the edge must be gently hammered so as to set it out all round, and the nose afterwards angle-faced in the usual manner.

The copper bush in the neck of vent-piece must be examined with a probe, to see that it is in good order, and that the gas has not made its way in between the pieces of which it is composed and displaced them. If the ·3″ gauge passes down the vent, it should be re-bushed.

Very considerable defects may exist on the exterior of a wrought-iron gun, without the strength being affected. Sometimes after firing a shifting of the coils takes place; if the movement is considerable, the gun should be provisionally condemned, but a slight shift, which is sometimes perceptible when the gun is first used, and which has gone no further afterwards, may be disregarded.

Gutta Percha for Impressions.—As long as free from grit or dirt may be used over and over again. It is first softened by being put into boiling water, then worked and kneaded on smooth board until the air and water are expelled, and an even surface is obtained. It is then placed upon the instrument and screwed up against the part of bore of which an impression is to be taken, and there left till cold—about fifteen or twenty minutes.

Care and Preservation of Carriages, &c.

Elevating Screws must be kept clean; and, if they do not run up and down freely, should be examined, and burrs on the teeth removed.

Sponge and Rammer Staves, and Handspikes, are liable to become splintered; should then be neatly smoothed down, to prevent the splints running into the gunners' hands. Side arms in store are likely to be attacked by small insects, who drill small holes in them and soon render them unserviceable.

Sponges when not in use are liable to be attacked by moth; to prevent their doing any serious damage, they should be examined occasionally, and well rubbed over with the hand and beat lightly with a wood mallet.

Wheels (Metal Naves).—Pipe-box sometimes get too much play on the axletree arm; this may be reduced by placing a leather wash in the recess.

If grit enters the pipe-box the wheel must be taken off, and pipe-box and axletree arm thoroughly cleaned.

Garrison Artillery Carriages (Iron).—All frictional surfaces must be kept properly cleaned and lubricated, and should be examined occasionally to ascertain if all the parts are sound and rigid and working properly. All nuts must be kept tightened up.

The friction roller of the elevating gear is liable to be set fast by corrosion; if so, it should be carefully removed and cleaned.

Hydraulic Buffer sometimes requires a new packing. Hemp well saturated with tallow makes a good packing.

If the piston-rod gets bent it must be removed from the buffer, and, unless much bent, can be straightened without being heated. This must be done with great accuracy and without indenting its surface.

Garrison Carriages (Wood) are most subject to decay about the trunnion holes, and where the bracket joins the axletree bed. All bolts and nuts must be kept thoroughly tightened up.

Gyns.—The wood windlass is liable to shrink from the barrels; it must then be removed, and the ends of the windlass packed with painted canvas to make the barrels firm and rigid.

Traversing gear should be worked at least once a week, to test its state, and also to change the position of the platform on the racers.

Painting.

Wooden Carriages.—Before proceeding to paint, the carriages must be cleaned from all mud and grease, and all blistered and perished paint and roughness of the surface must be scraped off. If any portion has been coated with grease or tar, after being well scraped, it must be washed with turpentine to make paint adhere.

The paint must be well worked down to the bottom of any cracks, and allowed twenty-four hours to dry before a fresh coat is put on.

Cracks, after receiving the coat of priming, must be "stopped," which must be well worked in.

Iron Carriages, before painting, must be stripped of all their loose parts, and thoroughly cleaned from old paint, rust, and corroded oil.

The shafts, spindles, wheels, elevating arcs, axles, piston-rod of hydraulic buffer, bearings, and frictional surfaces are not painted, but should be thoroughly cleaned and, except the teeth of wheels, made bright and oiled. The top surface of the sides of the platform and the bearing surface of the carriage are not

painted; should be made clean but not bright, and slightly coated with oil during practice. A little rust on the compressor plates and bars, if only superficial, is not detrimental.

Guns and garrison carriages are painted biennially.

Siege Train—War Establishment.

A siege train will consist of any number of units, composed of heavy or light ordnance, according to the requirements of the service, each unit consisting of the following guns, with 500 rounds of ammunition per gun, and stores in proportion.

Detail for a Heavy Siege Train Unit.—

Ordnance, R.M.L.	Guns	64-pounder,	64 cwt.	...	8	30
		40-pounder,	35 cwt.	...	8	
	Howitzers	8-inch	46 cwt.	...	14	

Seven of the howitzers will be provided with beds for vertical fire in addition to their travelling carriages.

Detail for a Light Siege Train Unit.—

Ordnance, R.M.L.	Guns	40-pounder,	35 cwt.	...	10	30
		25-pounder,	18 cwt.	...	10	
	Howitzers	6·3-inch	18 cwt.	...	10	

With each of the above units will be associated—six 7-pounder R.M.L. guns of 200 lbs.; three hundred 24-pounder Hale's rockets with six troughs.

III.

USE OF TANGENT SCALES AND SIGHTS: THE CONSTRUCTION AND GRADUATION OF THE FORMER.

Sights for R.M.L. Guns, 7-inch and upwards.

They are supplied with sights as follows, viz.—

1 Centre hind-sight.
1 Centre fore-sight.
2 Tangent scales.
2 Trunnion sights.

The "centre hind-sight" is of gun metal, and hexagonal in form; it works in a metal socket, fixed in the gun when mounted, but removed for transport. The sight is clamped by means of a set screw, which is not removable from the socket.

The "centre fore-sight" and "trunnion sights" are all of the "drop"pattern, fitting with a bayonet joint into gun-metal sockets, which latter are fixtures in the gun.

Tangent scales have flat steel bars, with gun-metal cross-heads, and sliding leaves for giving deflection. Those issued prior to December 1871, were fitted (for land service) with an elevating nut under the head, for the purpose of giving elevations less than ten minutes.

All sights are marked for the nature of gun for which they are intended, and they are all (both L.S. and S.S.) interchangeable between guns of the *same nature.*

Preservation of Sights.—When mounted in exposed positions, the whole of the sights should be removed from the guns and kept in store, the holes in the guns being filled with a plug of greased tow. Particular care should be taken that rust and grit do not accumulate in the sight recesses.

The sights themselves must be kept clean, free from grit, and oiled.

As the exposed portions of the sights are "bronzed" if made of gun metal, and "blued" if of steel, great care must be taken in cleaning not to remove either the bronzing or blueing.

The metal plates for trunnion sights of 80 and 64 pounders should be removed for transport, and the holes in the gun plugged up with preserving screws.

Preserving Screws.—Guns which have the "friction-tube pin" holes and the "guide-plate" hole filled by preserving screws should have the screws occasionally removed and oiled, to prevent their becoming fixed by rust.

Plates, Metal Elevating.—These are marked on the inner surface "R" and "L," to denote the side of the gun to which they belong. For transport, these plates should be removed, and the holes in the gun filled with preserving screws.

Use of Tangent Scales.

Degrees.—One side of all tangent scales has upon it a certain number of degrees, each degree being usually subdivided into six parts, each of these parts representing ten minutes—a minute therefore being $\frac{1}{60}$ of a degree.

A degree is always the $\frac{1}{360}$ part of the circumference of a circle. A degree on the tangent scale is $\frac{1}{360}$ of the circle, the centre of which is the apex of trunnion, of dispart, or of muzzle sight, having a radius from one of these three points, according to the position of the fore-sight on the gun, to rear of notch, or V, on the tangent sight.

Tangent Scale for 8-inch Howitzer, R.M.L.—Hence the degrees vary in length according to the position of the fore-sight, as will be seen by reference to the tangent scale of the 8-inch R.M.L. howitzer. In this howitzer the fore-sight is fixed on the end of the breech coil, and is used for elevations not exceeding 3°. The muzzle sight is used for elevation to 15°; consequently the first three degrees, being 360th parts of the circumference of a small circle, will be found to be shorter than the remaining degrees, which are 360th parts of the circumference of a larger circle, viz. with radius from V on tangent scale to apex of muzzle sight (see page 33).

Long and Short Radius.—For the same reason, the degrees on No. 1 wooden tangent scale, in use with Millar's sights for S.B. guns, are larger than those on tangent scale of hind-sight—the former being to the "long radius," viz. from tangent scale to muzzle; the latter being degrees of a circle with the "short radius," viz. from tangent scale to apex of dispart sight.

V's of Tangent Scale.—There are three descriptions of sights—full, medium, and fine.

Guns from 7-inch upwards have the full sight; siege guns, viz. 64-pounder, 40-pounder, 25-pounder R.M.L., and 8-inch howitzer R.M.L., are now to have the fine, though some of these are to be seen with medium or full sights.

Full Sights.—The full sight has its V ·15″ deep, and is wide at the top. With this the line of sight must be taken from the top of notch to apex of trunnion sight.

Medium Sight.—The medium sight has a narrower V, and the line of sight must be taken midway between the top and bottom of notch to apex of trunnion sight.

Fine Sight.—The fine sight has the narrowest V, is ·06″ deep, and the line of sight is taken from the bottom of V, or notch, to apex of trunnion sight.

Elevating Nut.—Tangent sights of all siege guns, 80-pounder and R.B.L., have an elevating nut (sights made for 7-inch guns and upwards since 1871 are not so provided, as it was not thought necessary by the navy), the circumference of which is graduated from 1 to 10, so that by turning it until the required number is in line with the arrow marked on the sight, any number of minutes elevation less than ten can be obtained.

Sliding Leaf, or Deflection Scale.—All tangent sights are provided with a sliding leaf, usually marked $\frac{1}{2}$ a degree, or 30 minutes, to the right and left of zero. As the tangent scales are set at an angle to the left to compensate for the lateral deviation, or permanent deflection, caused by the right-hand rifling, it is only necessary to use the deflection scale in order to allow for wind, one trunnion being lower than another, firing at moving objects, &c.

N.B.—For method of using the deflection scale, see chapter on "Ranges, Elevations, Pointing."

Use of Quadrant.—For firing at objects that cannot be seen, as in "indirect" or "high-angle" firing, or if tangent scale is useless, it will be generally necessary to give elevation by a quadrant. This instrument only gives angles of elevation or depression with reference to the horizontal plane; if, therefore, the gun is situated above or below the object to be fired at, it will be necessary, in the first place, to determine the angle of depression or elevation from gun to object. Where the object can be seen, this can be done readily by laying the gun point-blank at it, and thon determining the angle by quadrant. If the gun is below object, this angle will have to be added to that marked on range table; if above, subtracted. For example: For a certain range 5° of elevation would be required by tangent scale, what would be its equivalent by quadrant?

The gun is above the object, and, on testing, the angle of depression is found to be 1° 10′; then 5° — 1° 10′ equals 3° 50′, the angle to be given by quadrant.

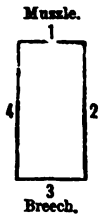
If the gun were this angle below the object, then 5 + 1° 10′, equal to 6° 10′, would be the angle to be given by quadrant.

Prussian Scales.—For night firing it is probable that an adaptation of these scales will be introduced, instead of the collimator, hitherto used for this purpose. The exact line of fire having been determined during the daytime and registered by these scales, and a chalk or painted line marked on platform in the direction of the line of fire, the gun can always be brought into the same position, and the elevation given by quadrant.

The principal object of having two sets of side sights is that, when guns are mounted on forts or on board ship, and traversed to extreme right or left, the sides of the port or embrasure would render the sight on the side of the gun nearest the work or side of the ship useless; the sights on the reverse side would then be ready for use. Also, in the case of one set of sights being damaged, the other is at hand, and spare sights are not required.

Construction of Sights.

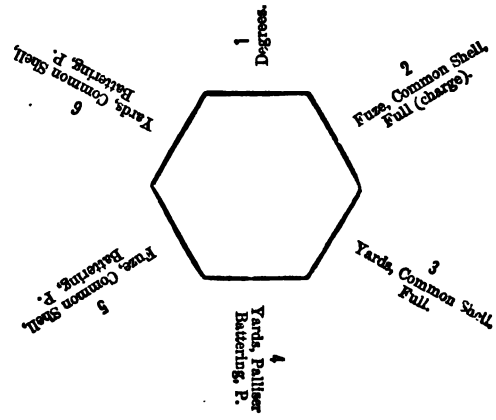
Tangent Sight, R.M.L., for 10-inch Guns and upwards.—The rectangular bars for tangent sights for 10-inch guns and upwards are, since October, 1871, thus graduated:—



1. Marked with degree scale.
2. „ „ yards and fuze for C. shell, full charge.
3. „ „ yards for Palliser shell, battering charge, P.
4. „ „ yards and fuze, C. shell, ditto, P.

For 7, 8, and 9 inch Guns.—The graduation of the tangent sights of 7-inch, 8-inch, and 9-inch guns is the same as the above, except that the yards scale on No. 4 is omitted and only the fuze scale engraved, as the ranges of all the projectiles with battering charges are the same, and No. 3 therefore serves the purpose. To prevent mistake the nature of the gun is marked on the tangent bar, as they are all the same in section.

Centre Hind-sights, for 10-*inch Guns and upwards.*—The centre sight is hexagonal and of gun metal, and is thus graduated for 10-inch guns and upwards:—



For 7, 8, *and* 9 *inch Guns.*—The centre hind-sights for 7, 8, and 9 inch guns are the same as the above, except that No. 6 is left blank for the two latter, and is graduated with a fuze scale for double shell for the 7-inch.

Tangent Sights for Guns below 7-*inch.*—The tangent sights for the 80-pounder, 64-pounders of 64 and 71 cwt, 40-pounder, and 25-pounder have the degree scale on side facing muzzle, the yards scale on opposite side, and fuze scale on a third side, and have elevating nuts.

For 64-*pounder*, 58 *cwt.*—The 64-pounder of 58 cwt. has the same scales marked on its centre hexagonal sight, but no sliding leaf or elevating nut.

For 8-*inch R.M.L. Howitzer.*—The tangent scale for this has only the degree scale.

Sights, R.B.L. Guns.—These sights are very similar to the R.M.L. tangent sights for guns below the 7-inch.

Most of them are the "barrel-headed" sights. In these sights the sliding leaf is traversed to the right or left by means of a screw, worked by milled-headed thumb-screws at each end of the barrel head. This screw is of such a pitch that the thumb-screws make a complete revolution in traversing the leaf ten

NATURE OF TANGENT SIGHTS AND GRADUATIONS FOR RIFLED GUNS.

	Nature of Gun.	Permanent Angle of Deflection of Sights.	Number of Degrees.	Number of Yards.	Twist of Rifling.	Number of Grooves.	
R.M.L.	16-inch, 80-ton	...	...	...	...	13	Centre and side sights.
	12·5 „ 38 „	2° 10′	...	...	0 to 1 in 35 cals.	9	
	12 „ 35 „	1° 25′	10	4800	„	9	
	12 „ 25 „	30′	12	4000	1 in 100 to 1 in 50	9	
	11 „ 25 „	2° 26′	12	3800	0 to 1 in 35	9	
	10 „ 18 „	1° 10′	12	4000	1 in 100 to 1 in 40	7	
	9 „ 12 „	44′	15	4000	0 to 1 in 45	6	
	8 „ 9 „	28′	15	4000	0 to 1 in 40	4	
	7 „ 7 and 6½ tons	3° 0′	15	4000	1 in 35	3	
	80-pr. (converted), 5 tons	19′	15	3500	1 in 40	3	Side sights only.
	64-pr. M.L. 64 cwts.	2° 50′	15	3600	„	3	„
	64-pr. M.L. converted 71 cwts. ...	2° 16′	15	3600	„	3	„
	64-pr. M.L. converted 58 cwts. ...	2° 16′	5	2000	„	3	Centre sights only.
	40-pr., 35 cwts.	1° 20′	12	4000	1 in 35	3	Side sights only.
	25-pr., 18 „	53′	12	4000	„	3	„
R.B.L.	7-inch, 82 cwts.	2° 16′	15	3600	1 in 37	76	„
	40-pr., 35 „	2° 16′	15	3800	1 in 36¼	56	„
	Howitzer, 6·3 inch	...	...	...	...	5	Centre sights.
	„ 8 „	variable	15	...	1 in 16	4	„
	„ 10 „	„	...	...	1 in 13	7	„

minutes, and, the circumference being graduated from 1 to 10, any required number of minutes can be accurately given.

For the present pattern the sliding leaf is traversed by hand, and clamped in the required position by a mill-headed screw on the front or muzzle side. This method has the advantage of lightness and cheapness, and is not so liable to become stiff in working.

Sights, S.B. Guns.—S.B. guns are now all provided with Millar's sights, which consist of a fore or dispart sight of gun metal, attached to gun by two screws, with a piece of lead between gun metal and gun to act as a buffer; a hind-sight of gun metal similarly attached, with a slot for the tangent scale to work in, the scale being fixed at an angle of 76° to the axis of gun.

The tangent scale is graduated to the short radius with degrees, half and quarter, up to the clearance angle.

For elevations above that, No. 1 wooden scale, similarly graduated, but to the long radius, is fixed on to the tangent scale.

With rifled guns the full or service charge gives a range of about 500 yards for one degree of elevation; with the battering charge, about 800 yards.

In future, all guns are to have the angle of permanent deflection stamped on the breech.

8-*inch Howitzer.*—The 8-inch howitzer has the tangent scale fixed perpendicularly to the axis of gun, and is fitted with a sliding leaf, marked 4° to the left and 1° to the right.

IV.

RANGES AND ELEVATIONS. POINTING AT FIXED AND MOVING OBJECTS.

Rules for Correction of Elevation and Deflection.—One minute increase of elevation gives an additional—

10 yards range, up to 500 yards.
7 „ from 500 to 1000 yards.
6 „ „ 1000 to 2000 yards.
5 „ above 2000 yards.

To correct error, divide error by one of the above figures, according to the range, for number of minutes for increased elevation or depression, as the case may be.

For Deflection.—Since one minute of deflection on the sliding leaf gives a difference of one inch in every hundred yards of range, the rule is: The error in inches, divided by hundreds of yards of range, gives the correction in minutes. Thus—

At 1000 yards range the shell is judged to strike two yards to right of object fired at.

2 yards = 72″; $72 \div 10 = 7$, the number of minutes to the left the sliding leaf will have to be set.

Position of Trunnions.—If one trunnion of a gun is lower than the other, the projectile will be thrown to the side of the lower trunnion.

Allowance for this should be made by the sliding leaf. A rough rule for this is: Multiply the number of inches that one trunnion is lower than the other by number of degrees of elevation, for correction in minutes.

To find Range from an Elevated Battery.—Height of battery in feet above plane on which object is situated, multiplied by 1146, divided by angle of depression in minutes, gives range in yards.

The angle of depression can be ascertained by means of a quadrant.

Mortars—to find the Charge required.—To range in yards add half the range, multiply result by ·03, and add 10 to product for charge in ounces, for 13-inch mortar.

Thus, if the range is 1000 yards—

Charge = $(1000 + 500)$ ·03 + 10 = 55 oz., or 3 lbs. 7 oz.

For 10-inch mortars, one half the above result.
For 8 „ „ one third „ „

Rule for Fuzes.—For length of fuze for mortars, add 17 to the number of hundreds of yards of range for tenths of fuze.

Old fuzes burn longer than those recently made.

Time fuzes in rifled projectiles fired against earthworks or wooden ships, &c., are driven into the shell, and usually explode it on impact without any boring.

Rule for Length of Rifled Time Fuzes.—Divide hundreds of yards of range by 2.

Up to 1000 add 1
From 1000 to 2000 „ 2 } for tenths of fuze for common shell.
From 2000 to 3000 „ 3

With the 9-sec. for shrapnel, one-tenth less.

For 5-sec.—Divide by 2 as before, and if over 1000 yards add 1 for shrapnel.

For S.B. Fuzes.—For shrapnel shell substract 6 from the hundreds of yards of range; for common shell substract 5.

To Lay a Gun.—To lay a gun is to direct it in such a manner that the top of the notch of the hind-sight, if a "full" sight (the bottom of the notch if a "fine" sight), the apex of the fore-sight (whether muzzle or trunnion), and the object are in line.

The scales having been adjusted, No. 1 should place himself in rear of the gun, his eye in line with the notch of hind-sight, and at least six inches from it, steadying himself by leaning his arm on the cascable.

He must avoid putting the back of the nail on the top of the sight, the hand to cover the eye, or holding the tangent scale.

The tone of his word of command should be a guide to his men how to move: when loud, they will work fast; when low, they will understand that the gun must be moved gently.

General Rules to be observed when Laying.—Get a clear view of the object, and see that the gun is approximately in the line of fire before looking over the sights.

Give a word of command to move the gun at the same instant that you look over the sights.

Always lay as quickly as possible, as the eye will not then become wearied.

Pointing at Fixed Objects.—Lay on the point to be struck with guns fitted with deflection scales, as all allowances for wind and difference of level in trunnions should be made by the scales, not by laying high or low, right or left.

With the 64-pounder R.M.L. (converted) and S.B. guns, allowance for the wind must be made by laying to the right or left of the object to be struck.

Pointing at Moving Objects.—If object is moving parallel to the front of the battery, first calculate the distance that the gun must be laid in front of the object, taking into consideration the time of flight of projectile and rate of motion of object; allow for this by deflection scale, and fire the gun as the object crosses the line of sight.

Thus, if firing with a 9-inch gun at a ship moving parallel to the battery at a speed of 6 knots an hour (a knot equals 2027 yards), at a range of 1000 yards the time of flight of projectile is 2·36 seconds, and during this time the ship will have moved 7·7 yards, or 277 inches; this number divided by 10, the hundreds of yards of range, gives 27, the number of minutes to set the sliding leaf to right or left, as required.

Laying Mortars.—Ranges of mortars are regulated by the charge, the elevation being constant at 45°.

Mortars are marked with a notch on the muzzle ring and one behind the vent.

If the platform is perfectly horizontal, the line joining these notches will mark the position of the axis of the mortar; if it is not horizontal, a line corresponding with the axis of the mortar, along the highest surface of it, must be found by means of the "perpendicular." In either case the line should be marked in chalk.

A mortar is correctly laid on an object when the axis of the mortar and the object are in the same vertical plane.

When the object can be seen from the mortar, it is laid direct on it.

If the object cannot be seen, two pointing rods are placed very carefully in a position from whence the object can be seen, so that the pointing rods, object, and centre of platform are in the same vertical plane. The mortar has then to be moved so that its axis is in the same vertical plane as the pointing rods. This is effected by No. 1 standing a little in rear of the platform, with a plummet line covering the pointing rods, and causing the mortar to be moved until its axis is likewise covered by the plummet line.

Boring Fuzes.—In boring, the fuze should be held in the left hand, head towards the body, the back of the hook of the borer downwards; the point of the bit being opposite to the mark, corresponding to the right number, so that the bit may be screwed home at right angles to the composition.

When firing with reduced charges, the ordinary priming must be supplemented with strands of gun cotton. To do this, uncap the fuze, open out the priming, and wind 10 or 12 inches

of the gun cotton round it, bringing the ends of the priming between the strands of gun cotton; then tie the two ends of the latter together, leaving about two inches loose, and fix the whole firmly by tying over it a piece of silk.

Breech-loading and percussion fuzes must be carefully screwed into the shell by the hand—never struck.

All other fuzes should be firmly fixed by smart taps with a mallet, &c. Care must be taken that the tape is not jammed.

Ricochet fire is of great value with S.B. guns, but cannot be used with rifled guns, as the direction of the projectile becomes most uncertain after it has struck an object.

CHARGES AND MUZZLE VELOCITIES OF ENGLISH ORDNANCE.

	Nature of Ordnance.	Battering Charge.		Full or Service Charge.		Projectile.		Muzzle Velocity.
		P.	R.L.G.	P.	R.L.G.	Nature.	Weight.	Feet per Second.
R.M.L.		lbs.	lbs.	lbs.	lbs.		lbs.	
	16-inch, 80 tons	1·5″ gr. 370	...	...	...	Palliser.	1700	1520
	12·5 „ 38 „	1·5″ gr. 130	...	...	...	„	800	1420
	12 „ 35 „	110 P.	...	85	...	„	700	1300
	12 „ 25 „	85	67	55	50	„	600	1300
	11 „ 25 „	85	70	60	50	„	535	1315
	10 „ 18 „	70	60	44	40	„	400	1364
	9 „ 12 „	50	43	...	30	„	250	1420
	8 „ 9 „	35	30	...	20	„	180	1413
	7 „ 7 „	30	22	...	14	„	115	1561
	80-pr., 5 tons (converted)	...	...	...	10	Common Shell.	80	1240
	64-prs. 64 cwt.	...	...	...	10, 12	„	64	12 lbs.-1458 10 lbs.-1376
	64-prs. converted 71 cwt.	...	...	...	8	„	64	1230
	64-prs. converted 58 cwt.	...	...	...	8	„	64	1245
	40-pr., 35 cwt.	...	...	...	7	„	40	1336
	25-pr., 18 „	...	...	...	4	„	25	1278
	Howitzer, 6·3 inch	...	...	...	...	„	64	
	„ 8 „	...	...	...	10, 5, 3	„	180	
	„ 10 „	...	...	...	...	„	400	
R.B.L.	7-inch, 82 cwt.	...	...	...	11	„	90	1165
	40-pr., 18 cwt.	...	...	...	5	„	41	1180
					L.G.			
S.B.	68-pr. 95 cwt.	...	...	...	16	Shot.	66	1500 to 1600
	8-inch, 65 cwt.	...	...	...	10	Shrapnel.	60	„
	32-pr., 58 or 56 cwt.	...	...	...	10	Shot.	32	„
Mortars.	13-inch, 36 cwt.	...	...	...	9			
	10 „ 18 cwt.	...	...	...	4			
	8 „ 9 cwt.	...	...	...	2			

V.

AMMUNITION AND CONSTRUCTION OF FUZES.

Gunpowder possesses for artillery purposes the following advantages over other known explosives, viz.:—

1. Progressive in action.
2. Regular. Equal charges produce same results.
3. Easily and, with due precautions, safely manufactured.
4. Safely used.
5. Not impaired by keeping when the magazines are dry.

Composition and Properties of Gunpowder.—75 saltpetre, 15 charcoal, 10 sulphur.

Explodes at about 600° Fahrenheit, but begins to deteriorate at 212°.

The burning of gunpowder is affected by the density, size, and shape of grain, and the condition of the charcoal.

For large charges, rapidity of ignition, so as at once to develop a considerable amount of gas, united with comparative slowness of combustion of the entire charge, is required.

The denser the gunpowder the slower it will be consumed.

A large grain burns slower than a number of small grains making up the same weight; but as large grains will not pack so closely together as small, in a large charge rapidity of ignition is obtained by use of the large grain, and this is united with the slowness of combustion of each grain.

A grain of regular shape offers less surface than an irregular one, so by the use of irregular-shaped grains rapidity of ignition is secured.

The purer the charcoal, the slower it burns, as it contains less oxygen and hydrogen.

The pressure exerted by the gas developed by the combustion of a charge of gunpowder in the bore of a gun may be considered to be from 22 to 25 tons upon the square inch.

Dangers to be avoided.—Gunpowder can be exploded either by a blow or by friction.

The harder the surface, the smaller the area struck, and the thinner the layer of powder, the more likely will the powder be to explode. This shows the advantage of covering

floors with some soft material when moving powder, and the necessity for perfect cleanliness. The sharp points of grit or sand coming in contact with powder dust would be just the most favourable conditions for an explosion.

Classification and Uses of the Various Kinds of Gunpowder.—P. Pebble. For all charges of 40lbs. and upwards. It is probable that powder about 1·5″ cube will be selected for 35, 38, and 80 ton guns.

R.L.G. Rifle large grain. For R.M.L. field artillery; also for battering charges of all guns when P. is not available.

Service L.G. Large grain. For all charges used with rifled ordnance, except field artillery, under 40lbs.

N.B.—When present stock of L.G. is finished, R.L.G. will take its place.

Service R.F.G. Rifle fine grain. For 7-pounder R.M.L. gun, rifled pistols, and bursting charge of shrapnel shells.

N.B.—Service F.G. and Service Pistol will, until finished, be used for bursting charges of shrapnel shell.

Service R.F.G.^{2}, for Martini-Henry rifle.

Mealed Powder is ordinary powder reduced to an impalpable dust; used on account of its easy ignition and rapid rate of burning. It is used where great regularity of burning is not required, as with quick-match, portfire composition, friction tubes, &c.

Pit-mealed Powder.—So called because it is made with gunpowder specially prepared with charcoal charred in pits, instead of in cylinders. Is used for fuzes, where great regularity of burning is required.

Gun Cotton is manufactured from cotton thoroughly cleansed, steeped in a solution of nitric and sulphuric acid; this is afterwards most carefully washed to get rid of all free acid, which would be fatal to its keeping qualities.

Its Use.—As it explodes at a much lower temperature than gunpowder, it is used for priming fuzes when very small charges are used, such as with double shells for 7-pounder gun, and for indirect or curved fire.

Gun cotton, if ignited by a blow, detonates with very great violence; it is also detonated by the action of various detonating bodies, such as fulminate of mercury, &c. This property renders gun cotton so valuable for torpedoes, destroying stockades, bridges, &c.

It is used as the explosive agent in the water shell.

AMMUNITION.

Cartridges, S.B.—Serge has been in general use for cartridges, as it consumes fairly in the gun and stands travelling well; it is not so safe when fired as blank.

Cartridges are made cylindrical for guns which have no chambers, such as 68-pounder, 32-pounder, &c., and conical for ordnance with gomer chambers, such as 8-inch, 10-inch (shell guns), howitzers, and mortars.

The cylindrical cartridge is made in one piece, the conical in two. To preserve the shape of the cartridge, it is hooped with worsted and then choked.

The diameter of the cartridge is less than that of the bore, to admit of easy loading, rapid ignition, and decreased pressure.

Shot guns, service charge from $\frac{1}{3}$ to $\frac{1}{4}$ weight of projectile.

Shell guns, $\frac{1}{6}$ to $\frac{1}{12}$.

Silk cartridges are used with S.B. guns for saluting, for sham fights, and for exercise in dismissing recruits.

B.L. Cartridges are made of serge; the bottom is formed with a circular piece, and the cylindrical part with a rectangular piece. They are hooped with blue braid.

Lubricator.—A lubricator, consisting of two thin cups of tinned iron soldered together, filled with a mixture of equal parts of tallow and linseed oil, attached to a wad of felt, the edges of which are coated with beeswax, backed by millboard, is inserted into the cartridge. It is put on the top of the powder in all cases, except the 40-pounder S.S. and 7-inch, which have their lubricators detached to save magazine room.

Wooden Socket.—With the 40-pounder S.S. and 7-inch, a varnished wooden socket is choked into the neck of the cartridge, on to which the lubricator screws. The use of the lubricator is to prevent the guns leading; the cups being broken by the discharge, the lubricant is squeezed out, and the wad, following, wipes and polishes the bore. The millboard serves as a support to the wad.

Paper Cylinder.—As the 7-inch, 40-pounder, and 20-pounder R.B.L. guns were originally intended to fire a larger charge than they now do, in order to bring the cartridge up to the length of the powder chamber a varnished paper cylinder is put inside. The cartridge is half filled with powder, then the paper cylinder, and then the rest of the charge. The wooden socket and paper cylinder are varnished, so that they should not absorb moisture.

The weight of the charge is $\frac{1}{3}$ that of the projectile, except for the 7-inch and 64-pounder R.B.L. guns.

R.M.L. Cartridges.—Are chiefly now of serge, but are all to be manufactured of silk cloth, which is both safer and stronger.

There are two natures of R.M.L. cartridges, viz. battering and full. The first would be used with Palliser projectiles; the second would be the ordinary charge used with all other projectiles.

When actually engaging an enemy from a casemate battery, or with a gun mounted on a Moncrieff carriage, it is advisable to use battering charges with all projectiles, the recoil being insufficient when the full charge is used. It would likewise be less confusing.

Pebble powder is used for all charges of 40lbs. and upwards, because it gives more velocity, with less strain upon the gun, than R.L.G. R.L.G., in the smaller charges, has similar advantages over L.G.; hence its introduction for rifled guns in place of L.G.

The serge cartridges are all hooped with blue braid.

Paint should *never* be used to mark cartridges, as it renders them liable to carry fire.

Battering charges of P. powder vary from about $\frac{1}{5}$ to $\frac{1}{6}$ the weight of projectile; the 7-inch is about $\frac{1}{4}$. Full charges, about $\frac{1}{3}$.

Primers, Shrapnel Shell.—In shrapnel shell from R. guns, a primer is used; it serves to convey the flash from the fuze to the powder, and also prevents the powder from working up into the fuze socket. It is now made of brass, filled with loose powder, the bottom being closed by a thin disc covered with shalloon.

Primers, Vent-Piece.—These are used for the 7-inch and 40-pounder R.B.L. guns; they are tubes of leather paper, driven with mealed powder, and pierced like a friction tube, having strands of red worsted attached, which keep the primer in the hole in the vent-piece. Their object is to convey the flash from friction tube to the cartridge.

Portfire.—Portfires would be used if the supply of friction tubes should fail. They consist of cylinders of stout paper filled with a composition of saltpetre, sulphur, and mealed powder. They burn from 12 to 15 minutes.

Quick Match is made of cotton wick, boiled with a solution of mealed powder and gum. It is principally used for priming fuzes. It burns at the rate of one yard in 13 seconds, but if enclosed in a tube of any kind, it burns about the rate of a train of gunpowder. When so enclosed in paper it is called

a "leader," and is used for firing a volley of rockets from the ground, &c.

Slow Match is made of pure hemp, slightly twisted and boiled in a solution of water and wood ashes. It burns at the rate of one yard in eight hours, and is used for lighting port-fires, &c.

Rivets are for securing wooden bottoms to S.B. shell. They are made of gun metal, hollowed out at the base, so as to expand into undercut holes in the shell.

Studs.—In all Woolwich guns the direction of the projectile and the rotation or twist are at present given by the bearing of the studs on the grooves.

Studs are, for most guns, made of an alloy of copper and tin; they are hollowed out at the base, and pressed into undercut holes.

All projectiles up to and inclusive of the 7-inch have three rows of studs, two studs in each row; the front and rear studs being equidistant in front and rear of the centre of gravity of the projectile.

As heavier projectiles require more points of support, those for the—

8-inch	gun	have	4	rows	of	studs.
9	„	„	„ 6	„		„
10	„	„	„ 7	„		„
11, 12, 12·5	„	„	„ 9	„		„
80-ton		„	„ 13	„		„

and in addition, the 35 and 38 ton guns have three studs in each row.

For all guns which have a uniform twist, that is, up to 7-inch inclusive, the front and rear row of studs are the same size. For those which have an increasing twist, the front stud must necessarily be made the smallest, otherwise the projectile would not pass through the bore, except by overriding the grooves or tearing off the studs.

The studs for the 64-pounder and 80-pounder R.M.L. are of pure copper, as the shells are greatly strained in pressing in the studs; for the 64-pounder, which has a very narrow groove, there are three in each row. For the 40-pounder R.M.L. the studs are of gun metal.

Tubes, Copper Friction.—There are three sizes, viz. the short friction tube for guns in general, a tube about 2 inches long for the 7-pounder, and the long friction tube, about 5 inches long, for 10-inch R.M.L. guns and upwards in the L.S.

The friction tube consists of a copper tube driven with mealed powder and pierced with a central hole, which gives a passage for the flash, and causes the tube to act instantaneously and violently. The top is stopped with shellac putty, and the bottom with a disc of varnished paper. A copper cylinder or "nib-piece" is fastened on to the tube near the top; into this is placed a copper friction bar, roughened and slightly turned up at one end, covered with a small patch of detonating composition. The nib-piece is pinched down so as to press on to the friction bar.

Action.—On pulling the lanyard (which should be stretched and then sharply pulled) the friction bar is drawn out, igniting the detonating composition, the fire from which passes through a hole which has been pierced in the copper tube, and ignites the mealed powder.

Tubes are *never to be placed in a magazine.*

Tubes, Quill Friction, are used for the navy, so as not to hurt men working with bare feet.

Tubes, Common Quill, are used when guns are fired by a port-fire. These might easily be manufactured on an emergency. Cut off point of quill, slit the top into 7 prongs, pass worsted alternately over and under each prong so as to form a cup. Drive tube with mealed powder damped with methylated spirits, and pierce hole throughout by a wire. Make a paste of mealed powder, gum, and water, and fill the cup with it, sprinkling dry mealed powder on to the top; twist a paper cap on to head of tube, and pass wire up tube again, to insure hole not being choked up. The tubes should be thoroughly dried, and must be uncapped before firing.

Tubes, Electric, are ignited by electricity and used for proof of guns, firing time-guns by electricity, &c.

Tin Cups, B.L. Guns, are used for all B.L. guns to prevent any escape of gas. They have a rim ·32″ deep, which is pressed back by the explosion of the powder against the sides of the bore, thus preventing the gas from getting behind them and damaging the vent-piece; generally used with 7-inch only.

Wood Bottoms for S.B. Guns are required with guns, for shells to keep the fuze, and with carcasses to keep the vents, in the proper position. They are made of elm or alder; for tropical climates, on account of the white ants, of teak. They are conical for all gomer chambered guns, and for unchambered guns of like calibre; cylindrical for other unchambered guns.

Wads, Wedge, are required for all R.M.L. guns on sliding carriages, to prevent the projectiles starting forward when the gun is run up.

They are of two sizes—the smaller for 64-pounder, 80-pounder, 7 and 8 inch; the larger for 9-inch and upwards.

The two wedges are connected by cane, so that it may bend readily to take the shape of the bore.

Wads, G.S., are made of papier mâché, with a hole in the centre covered by shalloon cemented to one side. The side covered with shalloon is placed downwards in the shell. It is used to prevent the powder from working up in the fuze socket of common rifled shell.

Wads, Papier Mâché, are used for fuze socket and loading hole of S.B. diaphragm shell and common shell, to keep the powder dry when the shells are likely to be kept for some time with the bursting charges in them.

Wads, Grummet, are used with S.B. guns when firing round shot at less than 3° or 4° elevation.

Projectiles, R.M.L. Guns.

Projectiles for these guns are cylindro-ogival in form; that is, the body is cylindrical, with an egg-shaped head. They should be at least two calibres in length to obtain accurate shooting, and should not be more than 3 calibres.

Palliser Shot and Shell.—Palliser projectiles are only made for guns intended to pierce ironclad ships, viz. 7-inch and upwards. It is probable that a Palliser shot of about 90lbs will soon be introduced for the 64-pounder R.M.L., with a 12lb. charge.

The shot differ from the shell in having a smaller interior space for the bursting charge.

Fuzes are not required for either shot or shell, as the bursting charge, when these projectiles are fired against ironclads, never fails to ignite, owing either to the great heat developed by the enormous force brought into play on the shell striking an iron plate, or to the bursting charge—which has, by the shock of discharge of the gun, been compressed into a solid cake—being thrown with the utmost violence against the head of the shell on the motion of the latter being suddenly stopped through coming into contact with an iron plate.

Palliser projectiles are chilled white nearly to the centre, the bodies being an even mottle throughout. This difference is obtained by casting the head in metal and the bodies in sand.

Metal, being a good conductor of heat, conducts the heat rapidly from the molten iron, leaving as a result a white fibrous iron, possessed of intense hardness, crushing strength, density, and brittleness. The body, cooled more slowly in sand, which is a bad conductor of heat, approximates nearer to the character of cast iron, and is less brittle than the chilled iron; therefore, when the projectile strikes an iron plate, the body is not so likely, as when the whole projectile was of chilled iron, to break away from the head, and thereby deprive the projectile of a great part of its energy.

Crushing strength differs from hardness in the manner that glass differs from iron. Glass is harder and will scratch iron, but the latter will readily crush the former.

Palliser shot and shell, and all common shell for rifled guns, are lacquered internally to decrease the chance of premature explosion. For the same reason, all Palliser shell, and common shell for guns above the 80-pounder, have bursters (flannel cartridges) put inside the shell. The 35-ton and 11-inch guns have only Palliser shell.

Palliser shell are known from the shot by being painted white at the top.

Shrapnel Shell.—Are not part of L.S. equipment for 7-inch guns and upwards, though made for all the heavy guns except the 11-inch, and issued for sea service. These guns, as a rule, are only mounted on sea fronts, and would repel boat attacks by case, using Palliser and common shell, as required, against ships.

All guns below the 7-inch are provided with shrapnel for land service.

These shell are now all made with the fuze socket flush at the top; this renders the head less liable to injury in transit. The socket is of gun metal, having the bottom tapped as a screw to receive the primer. The iron tube communicating to tin cup, in which the bursting charge is placed, fits on to the end of fuze socket.

The body is weakened internally by six longitudinal grooves running down the entire length of the interior, and forming lines of least resistance. The base is formed into a chamber to receive the bursting charge.

Over the mouth of the powder chamber is placed a wrought-iron disc, pierced in the centre for the iron tube to pass through.

Bullets of lead hardened with antimony fill up the space between the disc and head. For guns above the 80-pounder, sand shot are used. Rosin is run in amongst the bullets, and over them is placed a felt wad. The head is made of elm, bored out to con-

tain the socket, covered with a light shell of Bessemer metal; the body is of cast iron, the head being lightly attached to it by rivets and solder.

Use of Shrapnel.—Owing to the great distance to which rifled projectiles keep up their velocity, shrapnel will probably be very efficient as far as the 9-sec. fuze will act.

The shell may be burst as far as 300 yards from the object, but, if the troops are in close order, ought to be burst much nearer—about 100 yards.

Common Shell for 12, 11, 10, 9, 8, *and* 7 *inch* are of cast iron, about three calibres in length. Similarly to other shell, they have two extractor holes in the head, and are lacquered internally. The thickness of the walls varies from about $\frac{1}{5}$ in the larger to about $\frac{1}{8}$ of the diameter in the smaller shells. Those of late manufacture have their bases rounded off to facilitate loading. The gun-metal bush for fuze is countersunk. Many shell were made with an unloading hole, but as that tended to weaken the shell, it has been discontinued.

Common and shrapnel shell are cast with the base downwards, as that must be the strongest part; Palliser projectiles with the head downwards, so as to get the greatest density in that part which has to meet the greatest strain.

The Pettman G.S. fuze only is supplied for these shell.

Use.—Would be used against material generally. They would be most destructive against wooden ships.

Common Shell, 80, 64, *and* 40 *pounder.*—These shell are supplied with the 20-sec. and 9-sec. R.M.L. time fuzes, Pettman G.S., and R.L. percussion fuzes.

The 80-pounder has a band of increased thickness under the front row of studs, and the walls increase gradually in thickness towards the base.

The 40-pounder shell has the gun-metal socket flush with the top, not countersunk. In all other respects these shell are constructed similar to those for heavy guns.

Common Shell, 8 *and* 10 *inch Howitzers,* are similar to those for 8 and 10 inch guns, except that the studs are made to suit the quick uniform twist of the howitzers, which is necessary in order to give sufficient rapidity of rotation to the shell.

Double Shell, 7 *inch,* is nearly four calibres in length, and is strengthened by three ribs internally; otherwise, resembles the common shell.

It is intended for use against wooden ships, but, owing to its great length, is inaccurate at ranges over 2000 yards.

Case Shot is supplied for all R.M.L. guns. It is made of sheet iron tinned, with a wrought-iron disc in the bottom, and weighs about $\frac{3}{4}$ the service projectile. The interior is filled with sand shot; and in order to protect the rifling, and also to prevent the shot setting up and taking the rifling, three wrought-iron curved plates or segments are placed round the interior, resting on the wrought-iron disc.

The same case are used for the 80-pounder and 64-pounder; in the latest pattern for those guns the exterior is made in three parts soldered together, and six segments are put inside. R.M.L. case have no studs: except for the 7-inch, which has them, so that it may answer for the 7-inch B.L.

The body of the 40-pounder case is made of tin in three parts, soldered together, and the balls are of lead and antimony.

Use.—Case is effective up to 600 yards or more; the best results are obtained by using two case at moderate ranges.

About 1° elevation should be given when firing over water at a range of 500 yards.

Projectiles for R.B.L. Guns.

R.B.L. guns are supplied with shrapnel, common and segment shell, and case; the 20-pounder and 40-pounder, with solid shot.

The shrapnel, common shell, and case are similarly constructed to those for R.M.L. guns, except the lead coating in place of studs for the two first; and studs on the case to prevent it being rammed too far up the bore.

In loading with B.L. case, the studs go towards the rear, so as to bring the strongest part of the case next the charge.

Lead Coating.—In the Armstrong B.L. system, a soft-coated projectile larger than the bore is forced through a polygrooved bore, the lands of which cut their way into the soft coat, thereby constraining the projectile to take the rifling. The twist is in all cases uniform.

The lead coating is ·05″ thick over the body, and ·1″ over base, a cannelure running round the shell to take any lead stripping off the front part.

After the surface of projectile is thoroughly cleansed, it is dipped into a bath of zinc, then put into a mould, and molten lead poured in. The zinc makes a complete chemical attachment between the lead and iron.

The lead is apt to blister or get burred in transit; gentle hammering will get rid of the one, a file of the other.

Segment Shell is a very thin cast-iron shell, somewhat shorter than either common or shrapnel, on account of its increased weight lined with cast-iron segments, built up in layers, and having a cylindrical powder chamber in the centre; the base being closed with a cast-iron disc, which is retained in its place by the lead coating on the exterior flowing into a recess in the base.

Use.—These shells are very effective against troops in close order, or covered by shelter-trenches, garden walls, &c., and should in such cases be used with R.L. percussion fuzes.

Projectiles for S.B. Guns and Mortars.

Shot, Solid, are of cast iron, made for all S.B. ordnance, except shell guns, howitzers, and mortars.

Shot, Case.—Made for all S.B. ordnance, except mortars. Effective up to about 350 yards.

Shot, Grape.—Caffin's pattern. For all calibres of S.B. guns, not howitzers. Grape for 10-inch gun resembles case outside, but is filled with larger balls. Effective up to about 600 yards.

Sand Shot.—Principally for the manufacture of case and grape. Sometimes fired out of a mortar as pound shot, in which case a wooden bottom is necessary.

Shell, Common.—For S.B. guns, howitzers, carronades, and $5\frac{1}{2}$ and $4\frac{2}{5}$ inch mortars. They are about $\frac{1}{8}$ of their diameter in thickness, and weigh when empty about $\frac{2}{3}$ the weight of solid shot. They have a countersunk fuze hole, so that they could be used as hollow shot, with a rivet hole opposite to it.

The fuze hole is closed with a gun-metal plug, marked with a X to show that the thread is tapped throughout so as to receive a Pettman L.S. percussion fuze.

Shell, Naval, differ from the L.S. in having a larger fuze hole and two rivet holes.

Shell, Mortar.—For 13, 10, and 8 inch mortars. The fuze hole is larger than the L.S., and is not regularly tapped. They have no rivet hole, as they do not require bottoms to be attached.

Shell, Diaphragm Shrapnel.—For all calibres except the 10-inch. The shell is a thin cast-iron shell weakened by four grooves internally, thickened at the junction of diaphragm and shell, also at the fuze hole to support the socket, also at the base to

withstand the shock of discharge. A gun-metal plug to close the loading hole. A wrought-iron cup or diaphragm divides the shell into two unequal parts, the smaller for the bursting charge, the larger for the bullets, which are of lead hardened with antimony.

Shrapnel are always issued with the bullets in. "Filled" shrapnel would have the bursting charge as well.

Shrapnel from S.B. guns are not of much use over 1500 or 1600 yards.

Carcasses are fired from all S.B. ordnance to set fire to buildings, shipping, etc.

They are shells with three vents, $\frac{1}{8}$ their diameter in thickness, and are filled with carcass composition.

The vents are plugged with brown paper and kit plaster, which must be removed before firing.

Ground-light Balls are fired from mortars only, to discover an enemy's working parties. Star shell would be used for this purpose from rifled guns.

Parachute-light Balls.—As ground-light balls can easily be smothered by a few shovelfuls of earth, the parachute were introduced. They are only fired from mortars, and, being out of reach, cannot be extinguished. Careful allowance must be made for wind.

Hale's Rockets—Calibres, 9 and 24 pounders.

The latest pattern for 24-pounders is a thin cylindrical iron case, without any corrugations, fixed to head and base piece by strong rivets and screws; the interior is roughened, and lined with a case of brown paper and calico, coated with shellac. The tail-piece and vents (3 in number) are protected by a covering of leather, with calico outside, which must be removed before firing.

The onward movement of the rocket is caused by the gas, which presses equally in all directions, pressing against the head, while at the base it is free to escape through the three vents.

The rotatory motion round longer axis is imparted by the vents being cut away on one side, thereby resistance to the gas issuing from vents is only offered on side of each vent. As there is the same resistance and in the same direction at each vent, the rocket is compelled to rotate.

It is probable that, ere long, rockets with gun cotton in their heads will be introduced.

Fuzes.

There are three distinct classes of fuzes in the service—time, percussion, and electric; the latter being principally used for torpedoes, blasting, and proof of guns. Time fuzes would be principally used for shrapnel and common shell when employed to destroy material; percussion with common shell, sometimes shrapnel, against troops.

All time fuzes are now made of beechwood, and are conical in form, as this shape precludes all risk of the fuze setting back into the shell on the shock of firing.

Percussion fuzes are made of gun metal.

All time fuzes except the 5-sec. are filled with a composition of saltpetre, sublimed sulphur, and pit-mealed powder, which burns one inch in 5 seconds.

Electric detonators must *on no account* be *forced* into the gun cotton primers by screwing or twisting.

R.M.L. Fuzes.

All rifled fuzes, whether time or percussion, fit the G.S. gauge fuze hole.

All R.M.L. time fuzes have a gun-metal plug inserted into the head to prevent the rush of air, caused by the forward motion of the projectile, acting upon the composition, and thus making the times of burning irregular. This arrangement necessitates a groove to be cut round the neck of fuze, into which the priming (quick match) is wrapped; it then passes through two holes into the fuze, and is looped round the pin of the gun-metal plug. The priming in groove is protected by a copper band enclosed in tape and covered over with paper.

These fuzes are longer and thicker than the S.B. fuzes, so as to fit the G.S. gauge.

A paper lining coated with varnish is put round the composition channel to prevent the formation of a space between the composition and wood, in case of the latter shrinking from the effects of a hot climate.

In addition to the composition channel, there are in 5-sec. and 9-sec. fuzes two smaller channels, filled with rifle powder, and connected together at bottom of fuze by quick match.

9-*sec. Fuze* has two inches of composition; burns nominally 10 seconds. To each powder channel side holes are bored, protected by clay and varnished paper; those on one side being marked 2, 4, 6, to 18, on the other 3, 5, 7 to 19, dividing

the two inches of fuze composition into 20 parts. As 2 inches take 10 seconds to burn, $\frac{1}{20}$ will take half a second—or the fuze can be bored at periods of flight represented by half seconds.

This fuze is used for common and shrapnel shell.

20-*sec. Fuze* is used for common shell only. It has four inches of composition; burns 20 seconds; no powder channels. The numbers on the exterior commence at the end of second inch, and, like mortar fuzes, are placed spirally round the fuze.

5-*sec. Fuze* is specially constructed for use with shrapnel shell up to 80-pounder inclusive, and can be used with common shell when the time of flight does not exceed five seconds. It is in every way similar to the 9-sec., except that pit-mealed powder is used instead of fuze composition. Mealed powder burns at twice the rate of fuze composition, therefore two inches of the former burns in five seconds; and as the side holes are on the one side 1, 2, 3, 4, to 10, on the other 1·5, 2·5, to 9·5, the two inches of mealed powder (five seconds in time) are divided into twenty parts; therefore the rate of burning of each part is $\frac{1}{4}$ second, so the shells can be burst with much greater nicety for firing at moving objects.

Whenever these fuzes are used with very reduced charges, strands of gun cotton must be wrapped round the priming to insure ignition.

The R.M.L. time fuzes cannot be used with B.L. guns.

R.B.L. Time Fuzes.

5, 9, *and* 20 *sec.*—They are rather longer than the R.M.L., but resemble them in all other respects, except the substitution of the detonator for metal plug and priming round the exterior.

Detonator.—As there is no windage the fuze has to be ignited by a detonator. This consists of a cylinder of gun metal screwed into the head of the fuze. The cylinder contains a hammer supported by a copper wire; beneath the projecting portion of the hammer is a hollow containing a detonating composition, below which a hole passes to the priming of the fuze. The hammer is likewise supported by a safety pin, which is withdrawn by a tape just before placing the shell in the gun.

On shock of discharge the hammer is, as it were, thrown back and shears the supporting copper wire; its stem then enters the recess below, ignites the detonating composition therein, and thereby the priming and fuze composition is ignited.

To allow for the escape of the gas, three "escape" holes are made in the head, protected by thin copper discs and papier

mâché plugs, a piece of quick match being led up to each hole. These discs are blown out by the gas generated.

B.L. fuzes can be readily distinguished from the M.L. by the tape to safety pin, and by a label with a precautionary direction on the head. These fuzes must be screwed into the shell, and never struck. Force must not be employed to extract either them or percussion fuzes.

B.L. fuzes can be used with R.M.L. guns.

S.B. and Mortar Fuzes.

Diaphragm Shrapnel.—One inch of fuze composition. Side holes marked as in 9-sec. R.M.L. Powder channels connected at bottom of fuze with a piece of quick match.

Common S.B. Fuze.—Two inches of composition; in other respects similar to the diaphragm shrapnel, except that the powder channels are not united.

These fuzes cannot be used from rifled ordnance, as they are too small for the G.S. fuze hole.

Large Mortar Fuze.—For 13, 10, and 8 inch mortars. Has six inches of composition; no powder channels; the notation for boring marked spirally round the fuze, commencing at the end of second inch.

Small Mortar Fuze.—Similar to the above, but has only three inches of composition; notation commences at the end of first inch.

This fuze is intended for the $5\frac{1}{2}$ and $4\frac{2}{5}$ inch mortars, which fire gun common shell, so that this fuze can be used with common shell if necessary.

The two lower side holes of all time fuzes communicate direct to fuze composition, the others only to the powder channels.

Percussion Fuzes.

Pettman L.S.—This fuze acts on graze, and can only be used with S.B. shell for land service.

Construction.—The body is of gun metal, closed at top and bottom with metal plugs. Within the body are the steady plug, detonator ball, cone plug, and lead cup attached to the latter. The detonator ball is suspended between steady and cone plugs.

Action.—On firing, the shock of discharge crushes up the lead cup, which dovetails on to the projecting portion of bottom plug, and thereby firmly fixes the cone plug to body of fuze. The ball and steady plug are also set back, the former being prevented by the latter from touching the sides as it sets back (hence its name), but afterwards disengaging from steady plug owing to the irregular motion of the shell in the air. On graze or impact, the ball, now unsupported, is dashed violently against the side of the body, explodes the detonating composition, and fires the bursting charge, the flash passing through holes in the cone and bottom plugs.

Pettman G.S.—Can be used from a S.B. with naval shell, a R.B.L., or R.M.L. gun. It acts upon impact, not upon graze, such as on the side of a wooden ship or earthwork, and can therefore be used for naval purposes.

Construction.—The body is of gun metal, closed with a top plug, which has a small saucer-shaped hole in the centre, between which and a corresponding cavity in the top of steady plug rests a plain brass ball. The other contents are—steady plug, recessed at the top to contain detonating composition, which is covered over with a thin copper disc, pierced with three fire holes; detonator ball, covered with two thin copper hemispheres; cone plug, to which is attached a lead cup, supported by a copper wire, the projecting ends of which rest on the bottom of fuze. The fuze is closed at the bottom by the cone plug, covered by a cardboard disc.

Action.—On shock of discharge, the cone plug shears the copper wire, the lead cup is crushed up, and, dovetailing into the hollow round interior of base, prevents the cone plug rebounding.

The ball, steady plug, and plain brass ball are likewise set back. On striking, the action will be similar to the Pettman L.S.

In the event, as may occur in a B.L. gun, of the detonator ball not disengaging from the steady plug, ignition is insured by the steady plug, on impact, being dashed violently against the plain brass ball, and thus igniting the detonating composition in recess of steady plug.

R.L. Percussion.—Acts on graze; is intended for use in the L.S. with all B.L. shell having the G.S. fuze hole, and with all R.M.L. shell up to the 80-pounder inclusive. If used with guns firing heavier charges, the copper cap containing the detonating composition would be set back into the lead pellet, and could not be pierced by the needle.

Construction.—The body is of gun metal, with the bottom, which is screwed in, pierced with a fire hole. A steel needle point is fixed in the centre of head, which is also pierced to receive a safety pin. To prevent the flash of discharge entering at hole from which safety pin is withdrawn, a lead pellet is inserted in the head, above the safety pin. On ramming home, this pellet flies forward and closes hole.

Contents of fuse are a pellet made of lead and tin hollowed out, into the top of which, immediately under the needle point, is inserted a copper cap filled with detonating composition.

The guard, a collar of gun metal, fits over the pellet, and is recessed to receive its head, the top of recess being slightly undercut. The guard rests upon two feathers, or flanges, on the exterior of pellet.

The safety pin is of twisted wire, the two ends being separated at the end so that it may not come out too easily.

Action.—On shock of discharge, the guard is set back, shears the feathers, and the pellet expands into the undercut of guard, so that the two are united together. On graze, the pellet and guard fly forward, and the cap comes in contact with the needle, exploding the fuze.

None of these percussion fuzes will act with very reduced charges, as the force of discharge is not sufficient to prepare the fuze for action. A sensitive fuze will probably soon be introduced for high-angle firing, &c. When the shell are required to breach masonry or earth, the action of fuze will have to be somewhat restrained, to insure full penetration of shell previous to bursting.

N.B.—If unsafe when at practice to use the full bursting charge in shell, blowing charges are to be used. They are, for R.M.L. guns—

9-inch and upwards	...	...	1 lb.
8-inch and 7-inch	...	...	6 oz.
64-pounder	...	...	4 oz.

For R.B.L. guns, the shell to be filled with a mixture of one part of gunpowder to three parts of granulated coal dust.

Gas Checks, attached to base of projectile, will probably soon be adopted for R.M.L. guns. They decrease windage, thereby preventing scoring, and may ultimately be the means, instead of studs, for giving rotation to projectiles.

VI.

PACKING OF AMMUNITION AND STORES IN STORE ROOMS AND MAGAZINES.

Store Rooms.—The "Cartridge Store" is intended for filled cartridges; the "Shell Store" for filled shell.

"Expense Cartridge" or "Expense Shell Stores" are those appropriated for the service of particular guns.

A "Cartridge" or a "Shell Recess" is a small receptacle for the storage of a few cartridges or shell for the immediate service of a gun.

In the "Artillery General Store" are placed spare stores of all natures.

In the "Artillery Store for Small Stores" are placed the sights, elevating arcs, and other small stores belonging to the guns and required for their immediate service.

Cases and Barrels.—The cases and barrels chiefly used are—

1. Metal-lined cases.
2. Gun ammunition barrels.
3. Zinc cylinders.
4. Powder barrels.

Metal-lined Cases are of three sizes, whole, half, and quarter; the two last being chiefly used by the navy.

They are used in damp magazines and siege trains for holding filled cartridges. The bung should be "luted" into its place when the case is full.

Gun Ammunition Barrels are of two sizes, whole and half. They are not intended to contain loose powder. They are used in dry magazines to contain cartridges. No luting is used to close the lid.

Zinc Cylinders are used to contain the cartridges of the 7-inch guns and upwards.

They are hoisted up the powder lifts in metal cages.

Powder Barrels are of three sizes, whole, half, and quarter, and are used to contain loose powder, and occasionally to hold gun ammunition; they hold respectively 100lbs., 50lbs., and 25lbs. Owing to the greater density of "P." powder, the whole barrel holds 125lbs. of "P."

Powder to be sent by rail is put in a flannel bag and placed

in a half or quarter barrel. The barrel is covered by a canvas bag, and placed in an iron case or cylinder.

Budge Barrel is a quarter powder barrel with only one head, the other being replaced by a leather bag, the mouth of which is closed by a leather thong. Used for holding loose powder for mortars.

Care and Stowage of Gunpowder.

In stacking barrels or cases of ammunition, a space is to be left between them and the wall of the magazine, to allow a free circulation of air.

No friction, detonating, or common tubes; small-arm ammunition, or the powder from it after being broken up; quick or slow match; signal lights, rockets, or primers, will be allowed in any magazine or cartridge store, or admitted within the enclosure of a magazine where gunpowder alone is stored.

Oiled rags, cotton waste, oakum, or cloths for cleaning are not to be kept in magazines, ammunition stores, or passages.

Barrels containing powder are not to be rolled along the floors of magazines or passages, but are to be carefully carried from one place to another.

No laboratory operations, no packing or shifting of cartridges, or issue of powder from cases or barrels are allowed within the block containing the magazine or cartridge stores. These operations are only to be carried on in the laboratory.

The floor of a magazine or ammunition store must be kept scrupulously clean, and free from loose grains of powder. The passages must be covered with hides, wadmil-tilts, or hair cloths, when powder in bulk is being moved; these coverings should be frequently lifted and dusted.

Upon the earliest appearance of a thunder-storm, the doors and ventilators of a magazine should be immediately closed.

All empty ammunition or powder barrels should be most carefully examined to see that they are free from iron tacks in the head, and grit and dirt on the staves.

All persons employed in a magazine or laboratory must, before entering, change their own clothes and boots for magazine clothing and slippers. This must be done in the place appointed for shifting.

Every barrel or case should be carefully examined, and if imperfectly closed, or if any iron nails are fastened into it, it *must not* be received into the magazine.

Powder from shells, whether it has been in bags or not, must be wetted and reserved for extraction of the saltpetre.

Magazines which are found to be damp may be improved by the use of quicklime. The lime should be fresh from the kiln, broken into lumps not larger than about the size of a pigeon's egg, and exposed to the air of the interior of the magazine in shallow vessels.

Making up Cartridges, Filling Shell, and Examining Ammunition.

Filling shell and making up cartridges are never to be carried on at the same time, in the same place.

Any loose grains of powder, dust, or grit must be at once swept up.

All persons employed must divest themselves of their boots, lucifer matches, &c.

All shells, previous to filling, must be carefully searched internally, and all loose filings or pieces of lacquer removed.

Powder barrels and zinc cylinders containing cartridges should be conveyed to the laboratory in barrows, to keep them free from dirt or grit.

Not more than the equivalent to two barrels of powder should be in the laboratory, or in transit between the magazine and laboratory, at the same time.

All filled shell should be plainly marked as such.

In heading or unheading powder barrels, the bare adze should never be used against the copper hoops—a wooden-handled metal setter must be applied.

None but the authorized lamps are to be used for lighting magazines, &c.

THE END.

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